Popular Astronomy.

Vol. XX, No. 2. FEBRUARY, 1912. Whole No., 192

A MERCATOR'S PROJECTION OF MARS.

LATIMER J. WILSON.

The material for the Mercator's Projection for the planet Mars, has been obtained from one hundred and twenty-four telescope sketches, covering the period from October 26 to December 29, 1911. Longitudes were calculated from these dates only, as the greatest amount of detail was seen in that interval. The map is intended to give a general idea of Mars as it appeared during the recent oppositon. My eleven-inch reflector is not driven by a clock and precise measurements were, of course, out of the question.

Nearly all the detail of the Mare Sirenum region was seen on the nights of December 5 and 6. The canals were about as shown on the map, and were closely matted, when not well seen, presenting an appearance of greenish shading on the planet's disc. Intense white spots in tropical regions, an instance of which is the white preceding the Syrtis—evidently the "Nix Atlantica" of Schiaparelli, seem to remain. A white spot north of the Trivium Charontes has also been conspicuous. Mare Acidalum was partly covered with white on November 15, and is thus shown on the map. The northern cap is shown at about its maximum, as far as my observations are concerned.

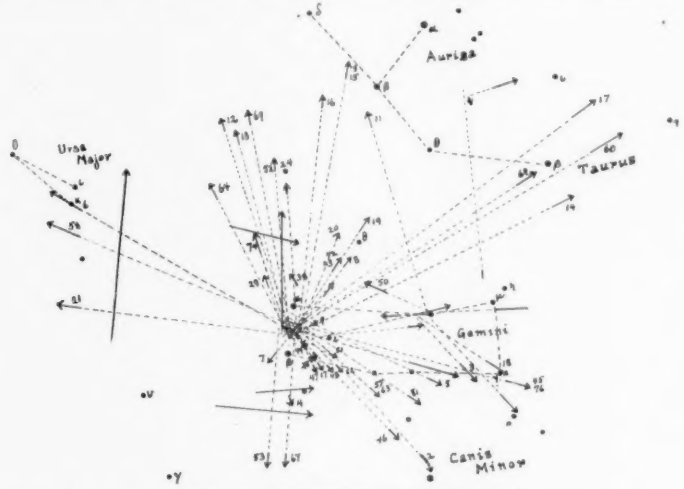
Nashville, Tennessee.

THE GEMINIDS 1911.

R. M. DOLE.

December 11 was foggy with an occasional glimpse of clear sky. Nine Geminids were seen between 10:00 and 11:15. December 12 was a very poor observing night, the sky being both overcast and foggy almost the entire evening, and after 12 completely overcast. An occasional clear space showed Gemini, Auriga and Taurus. In spite of this handicap 19 were observed and their positions accurately noted. December 13 was a sparkling clear night, and 51 Geminids, 4 Aurigids, 5 Cancrids and two Leonids were seen between 10:45 and 1:00. The Geminids were short, rather slow and therefore very easy to chart on a map. An unusual number were seen near the radi-

ant point, which was half way between α and β and half way between ι and α Gemini. It was evident that the radiant was not strictly a point but an area, and from December 12 to



GEMINIDS, DECEMBER 11, 12, 13, 1911.

December 13 the area had shifted N. E. The colors of the Geminids were blue, red, yellow or yellow white and white. Two of the brightest were bright yellow; but one left a perceptible trail. According to brightness they were as follows:

Magnitude	−2	−1	0	1	2	3	4	5	6
Number	1	0	9	12	11	21	7	2	19

Blue 2, red 7, 2 very yellow and the rest white or whitish yellow. Total 82 Geminids, 12 others.

Geminids		Others	Notes
Dec. 4	1	—	Moon near
Dec. 11		1 Aurigid	Foggy
10-10:30	4	1 Leonid	Very foggy
10:30-11:15	5	1 Cancrid	
Dec. 12			
9:50-10:00	3	1 Cancrid	Dense fog
10:00-11:00	8	1 Aurigid	Dense fog
11:00-11:30	3	1 Cancrid	Clear near Gemini
11:30-12:00	7		All cloudy except Gemini
Dec. 13			
10:45-11:00	8	1 Aurigid	Clear
11:00-11:30	11	1 Aurigid	Clear
11:30-12:00	7	3 Cancrids	Clear
12:00-12:30	8	1 Leonid	
12:30-1:00	17		

Jamaica Plain, Mass. 91 Glen Road.

CAPTURE THEORY AND CAPTURE PRACTICE.

F. R. MOULTON.

In the second* exposition of the Capture Theory in POPULAR ASTRONOMY, which is now appearing, Dr. See has again asserted that I have been guilty of an erroneous application of Jacobi's integral in the restricted problem of three bodies. In order that continual repetition of this statement may not lead any one to suppose that the criticism is just, it seems to be necessary, disagreeable as the task is, to make a few comments on the subject of this integral as it appears in his book entitled The Capture Theory of Cosmical Evolution. All that he has written respecting Jacobi's integral appears in his chapters VIII, IX, and X (pp. 159-237), and, with the exception of a single equation which I will later discuss, has been captured almost literally from the seventh chapter of my "Introduction to Celestial Mechanics," published in 1902. To be specific, his equations (206), (208), (210), (212), (214), (215), (216), (217), (218), (219), (222), (223), (224), (241), (244), (246), (247), (266,) (267), (269), (270), (271), (272), (273), (280), (281), (282), (283), (284), and (285) are, except for trivial changes of notation, respectively equations (1), (2), (3), (4), (5), (6), (7), (8), (8), (9), (10), (11), (7), (7), (25), (26), (27), (6), (5), (2), (7), (8), (9), (10), (12), (13), (14), (15), (16,) and (22) of the seventh chapter of my Celestial Mechanics. Many other equations in these chapters of the Capture Theory have also been taken from my book, but as I gave them no numbers it is not convenient to make the cross references. In no place whatever is there a hint that the Capture Theory is indebted to the Celestial Mechanics for this material.

The explanations of the derivation and meaning of these equations, so far as the form is concerned, have also been captured from my book with only slight, but for the actual meaning often fatal, alterations. In order that the reader may judge for himself in this matter, I will quote pages 228, 229, and the first six lines of 230 of the exposition in the Capture Theory, and also the corresponding exposition from my Celestial Mechanics which was published eight years earlier. To make the comparison easy they are here printed on opposite pages.

* The first exposition was published in POPULAR ASTRONOMY during 1909-1910.

[*From pages 228, 229, and 230 of the Capture Theory, published in 1910.*]

"The value of the constant in the Integral of Jacobi could be determined by several methods, but we shall consider only the simplest of the processes, depending on the use of bi-polar coördinates. The centers of the bodies $1-\mu$ and μ will be taken as the poles, and the radii vectores ρ_1 and ρ_2 the distances from the sepoles, the origin, as before, being the center of gravity of the system. Then, since the distance of the bodies from the center of gravity is inversely as their masses, it is evident that we shall have $O\mu = 1-\mu$, $\overline{O(1-\mu)} = -\mu$; and the values of y referred to the two poles are:

$$\left.\begin{aligned} y^2 &= \rho_1^2 - (x+\mu)^2 = \rho_1^2 - x^2 - 2\mu x - \mu^2, \\ y^2 &= \rho_2^2 - \{x-(1-\mu)\}^2 = \rho_2^2 - x^2 + 2(1-\mu)x - (1-\mu)^2. \end{aligned}\right\} \quad (278)$$

Equating the right members of these expressions, we find $2x = \rho_1^2 - \rho_2^2 + 1 - 2\mu$. The original equations (278) then give

$$x^2 + y^2 = (1-\mu)\rho_1^2 + \mu\rho_2^2 - \mu(1-\mu); \quad (279)$$

and the integral of Jacobi giving the curves on the xy-plane becomes

$$(1-\mu)\left(\rho_1^2 + \frac{2}{\rho_1}\right) + \mu\left(\rho_2^2 + \frac{2}{\rho_2}\right) = C + \mu(1-\mu) = C'. \quad (280)$$

Now, since $\mu \leq \frac{1}{2}$, and the first term, therefore, is always positive, the expression shows that C' is always greater than $\mu\left(\rho_2^2 + \frac{2}{\rho_2}\right)$, for all real and positive values of the radii vectores ρ_1 and ρ_2. If fixed numerical values of C' be adopted, and the arbitrary values of ρ_2 assigned, equation (280) enables us to find the corresponding values of ρ_1. This is the same as drawing arbitrary circles about the planet and calculating the corresponding radii vectores of the circles about the center of the Sun, and from their intersections finding points on the curves traced by the energy surfaces in the xy-plane. Equation (280) may be written in the form

[*From article 120, pages 194 and 195, of Moulton's Celestial Mechanics published in 1902.*]

"The latter difficulty can be avoided entirely, and the degree of the equation very much reduced by transforming to bi-polar coördinates. That is, points on the curves may be defined by giving their distances from two fixed points on the x-axis. This method could not be applied if the curves were not symmetrical with respect to the axis on which the poles lie. Let the centers of the bodies $1-\mu$ and μ be taken as the poles; the distances from these points are r_1 and r_2 respectively. To complete the transformation it is only necessary to express x^2+y^2 in the terms of these quantities.

Let P be a point on one of the curves; then $OA = x$ $AP = y$, and, since O is the center of mass of $1-\mu$ and μ, $\overline{O\mu} = 1-\mu$, and $\overline{O(1-\mu)} = -\mu$. It follows that

$$y^2 = r_1^2 - (x+\mu)^2 = r_1^2 - x^2 - 2\mu x - \mu^2,$$
$$y^2 = r_2^2 - \{x-(1-\mu)\}^2 = r_2^2 - x^2 + 2(1-\mu)x - (1-\mu)^2.$$

Eliminating x from these equations, and solving for x^2+y^2, it is found that

$$x^2+y^2 = (1-\mu)\,r_1^2 + \mu r_2^2 - \mu(1-\mu).$$

As a consequence of this equation, (9) becomes

$$(12) \qquad (1-\mu)\left(r_1^2 + \frac{2}{r_1}\right) + \mu\left(r_2^2 + \frac{2}{r_2}\right) = C + \mu(1-\mu) = C'.$$

If an arbitrary value of r_2 be assumed r_1 may be computed from this equation; the points of intersection of the circles around $1-\mu$ and μ as centers, with the computed and assumed values respectively of r_1 and r_2 as radii, will be points on the curves. To follow out this plan, equation (12) may be written

[*From the Capture Theory*]

$$\left.\begin{aligned} &\rho_1^3 + a\rho_1 + b = 0, \\ &a = -\frac{C}{1-\mu} + \frac{\mu}{1-\mu}\left(\rho_2^2 + \frac{2}{\rho_2}\right), \\ &b = 2. \end{aligned}\right\} \qquad (281)$$

As $\mu \leqq \frac{1}{2}$, and C' is greater than $\mu\left(\rho_2 + \frac{2}{\rho_2}\right)$, a is always negative; and the cubic in ρ_1 is shown in the Theory of Equations to come under CARDAN'S *irreducible case*, all the roots being real and positive, with the following trigonometric solution (cf. CHAUVENET'S *Trigonometry*, p. 100):

$$\left.\begin{aligned} &\sin\phi = \frac{b}{2}\sqrt{\frac{27}{-a^3}}, \quad \phi \leqq \frac{\pi}{2}, \\ &\rho_{1,1} = 2\sqrt{\frac{-a}{3}}\,\sin\frac{\phi}{3}, \\ &\rho_{1,2} = 2\sqrt{\frac{-a}{3}}\,\sin\left(60° - \frac{\phi}{3}\right), \\ &\rho_{1,3} = -2\sqrt{\frac{-a}{3}}\,\sin\left(60° + \frac{\phi}{3}\right). \end{aligned}\right\} \qquad (282)$$

where $\rho_{1,1}$, $\rho_{1,2}$, $\rho_{1,3}$ are the three roots of the cubic, corresponding to the different values of the angle ϕ which have the same sine. The negative root $\rho_{1,3}$ may, of course, be neglected. In this case

$$-4a^3 \geqq 27\,b^2; \text{ or since } b = 2, -a^3 \geqq 27, \text{ or } a + 3 \leqq 0 \qquad (283)$$

The limit of this inequality is $a' = -3$, and if we use this in the second equation of (281), we have the extreme values of ρ_2 for which the roots are real:

$$\left.\begin{aligned} &\rho_2^3 + a'\rho_2 + b' = 0, \\ &a' = -\frac{C'}{\mu} + \frac{3(1-\mu)}{\mu}, \\ &b' = 2. \end{aligned}\right\} \qquad (284)$$

If $a' \leqq -3$, the roots are real, and

[*From the Celestial Mechanics*]

$$(13)\qquad \begin{cases} r_1^3 + ar_1 + b = 0, \\ a = -\dfrac{C'}{1-\mu} + \dfrac{\mu}{1-\mu}\left(r_2^2 + \dfrac{2}{r_2}\right), \\ b = 2. \end{cases}$$

It follows from (12) that C' is always greater than $\mu\left(r_2^2 + \dfrac{2}{r_2}\right)$ for all real positive values of r_1 and r_2; therefore a is always negative. It is shown in the Theory of Equations that the cubic equation of this form may be solved by means of trigonometric functions as follows*:

$$(14)\qquad \begin{cases} \sin\theta = \dfrac{b}{2}\sqrt{\dfrac{27}{-a^3}}, \quad \theta \leqq \dfrac{\pi}{2}, \\ r_{11} = 2\sqrt{\dfrac{-a}{3}}\,\sin\dfrac{\theta}{3}, \\ r_{12} = 2\sqrt{\dfrac{-a}{3}}\,\sin\left(60^\circ - \dfrac{\theta}{3}\right), \\ r_{13} = -2\sqrt{\dfrac{-a}{3}}\,\sin\left(60^\circ + \dfrac{\theta}{3}\right), \end{cases}$$

where r_{11}, r_{12}, r_{13} are the three roots of the cubic.

The only values of r_1 and r_2 having a meaning in this problem are real and positive. It follows from the definition of θ that the three roots are real only if

$$-4a^3 \geqq 27\,b^2;$$

or, since $b = 2$, if

$$(15)\qquad a + 3 \leqq 0.$$

The root r_{13} is negative and need not be considered. The limit of the inequality (15) is $a + 3 = 0$; or, in terms of the original quantities,

$$(16)\qquad \begin{cases} r_2^3 + a'r_2 + b' = 0, \\ a' = -\dfrac{C'}{\mu} + \dfrac{3(1-\mu)}{\mu}, \\ b' = 2. \end{cases}$$

* See Chauvenet's *Plane and Spherical Trigonometry*, p. 100.

[*From the Capture Theory*]

$$-\frac{C'}{\mu}+\frac{3(1-\mu)}{\mu}=-3, \text{ or } C'=3.$$

This is the minimum value of C' that will permit the curves to have real points in the xy-plane; and for these values $\rho_1=1$, $\rho_2=1$, satisfy the equation (280), and the surfaces just touch the xy-plane at the points which form equilateral triangles upon SJ as a base. It is easily shown that when the mass μ is very small, as is the case in the solar system, we may expand the expression for ρ_2 in a power series in $\mu^{\frac{1}{3}}$; namely,

$$\rho_2=a_1\mu^{\frac{1}{3}}+a_2\mu^{\frac{2}{3}}+a_3\mu^{\frac{3}{3}}\ .....$$

For points on the x-axis between x_2 and x_1 the coefficients are found to be

$$\left.\begin{aligned} &a_1=\frac{3^{\frac{2}{3}}}{3};\ a_2=\frac{-3^{\frac{1}{3}}}{9};\ a_3=-\frac{1}{27}, \text{ etc.,}\\ \text{and}\quad &\rho_2=\mu^{\frac{1}{3}}\left\{\frac{3^{\frac{2}{3}}}{3}-\frac{(3\mu)^{\frac{1}{3}}}{9}-\frac{\mu^{\frac{2}{3}}}{27}\ .....\right\}\\ &\rho_1=1-\rho_2. \end{aligned}\right\} \qquad (285)$$

Having found ρ_2 and ρ_1 by these equations, the corresponding value of C' is found by (280), which also gives the constant of the Jacobian integral $C=C'-\mu(1-\mu)$. The formulae for investigating the details of the curves of zero velocity throughout their whole course need not be given here, as the subject is an extensive one; they will be found in works on periodic orbits and kindred subjects."

[*From the Celestial Mechanics*]

The solution of this equation gives the extreme values of r_2 for which (13) has real roots. Therefore, in the actual computation equation (16) should first be solved for r_{21} and r_{22}. The values of r_2 to be substituted in (13) should be chosen at convenient intervals between these roots. Equation (16) will not have real roots for all values of a', the condition of real roots being

$$a' + 3 \leq 0;$$

the limiting value of which is, in the original quantities,

$$-\frac{C'}{\mu} + \frac{3(1-\mu)}{\mu} = -3;$$

whence

$$C' = 3.$$

Therefore C' must be equal to, or greater than, 3 in order that the curves may have real points in the xy-plane. For $C' = 3$ the curves are just vanishing from the plane, and it follows at once that equation (12) is then satisfied by $r_1 = 1$, $r_2 = 1$; that is, the surfaces vanish from the plane at the points which form equilateral triangles with $1 - \mu$ and μ."

[*The following is from article 121 of the Celestial Mechanics.*]

"(a) At the double point on the x-axis between $+\infty$ and x_2, $x - x_2 = r_2$, $x - x_1 = r_1 = 1 + r_2$, $x = 1 - \mu + r_2$; therefore the first equation of (19) becomes after clearing of fractions

$$r_2^5 + (3-\mu)\, r_2^4 + (3-2\mu)\, r_2^3 - \mu\, r_2^2 - 2\,\mu r_2 - \mu = 0. \tag{20}$$

This quintic equation has one variation in the sign of its coefficients, and hence only one real positive root. The value of this root depends upon μ. Consider the left member of the equation as a function of r_2 and μ. For $\mu = 0$ the equation becomes

$$r_2^3 (r_2^2 + 3r_2 + 3) = 0,$$

[*From the Celestial Mechanics*]

which has three roots $r_2 = 0$, and two others, coming from the second factor, which are complex. It follows from the theory of the solution of algebraic equations that, for μ different from zero but sufficiently small, three roots of the equation are expressible as power series in $\mu^{\frac{1}{3}}$, vanishing with this parameter.* The one of these three roots obtained by taking the real value of $\mu^{\frac{1}{3}}$ is real; the other two are complex. Therefore, the real root has the form

$$r_2 = a_1 \mu^{\frac{1}{3}} + a_2 \mu^{\frac{2}{3}} + a_3 \mu^{\frac{3}{3}} + \ldots\ldots$$

Substituting this expression for r_2 in (20) and equating to zero the coefficients of the different powers of $\mu^{\frac{1}{3}}$, it is found that

$$a_1 = \frac{3^{\frac{2}{3}}}{3}, \quad a_2 = \frac{3^{\frac{1}{3}}}{9}, \quad a_3 = -\frac{1}{27}, \ldots\ldots$$

Hence

$$(21) \qquad \begin{cases} r_2 = \mu^{\frac{1}{3}} \left(\dfrac{3^{\frac{2}{3}}}{3} + \dfrac{(3\mu)^{\frac{1}{3}}}{9} - \dfrac{\mu^{\frac{2}{3}}}{27} \ldots\ldots \right), \\ r_1 = 1 + r_2. \end{cases}$$

The corresponding value of C' is found by substituting these values of r_1 and r_2 in equation (12)."†

Not only have many equations and explanations been captured from my Celestial Mechanics, but also a number of

* See Harkness and Morley's *Theory of Functions*, Chapter IV.

† Equations (285) of the Capture Theory were captured from the case (*b*) in my book, which is treated just like that quoted here, and whose results alone are given in my equation (22). This development in series was new in the Celestial Mechanics.

figures, with all their defects of proportion, without any reference to their source. In illustration of this fact FIG. 31 from my book and FIG. 19 of the Capture Theory are photographically reproduced on page 78 and 79. It should be stated that this figure appeared first in my book and has not been printed elsewhere until it turned up in the Capture(*d*) Theory.

The part of the one article which has been quoted from the Capture Theory is no nearer like the corresponding parts of my Celestial Mechanics than are its articles 82, 83, 84, 85, 86, 87, 91, 102, 103, and 108, while there is the same similarity in the case of other figures. The only reference to my Celestial Mechanics in the whole Capture Theory is at the end of article 85, p. 171 in chapter VIII, 57 quarto pages before the quotation from Chapter X which has been given here, where we read "A brief account of these surfaces may be found also in Moulton's 'Introduction to Celestial Mechanics', pp. 193-196". Ah! Indeed!

The quotations which have been given show with what success the form of my exposition, even in its minute details of printing, has been captured, but the meanings of the equations and the figures, unfortunately, have not been so fully captured. It would have been much better from the standpoint of accuracy if absolutely literal appropriation of this matter had been made. In order to establish this fact let us examine the part of the one article which has been quoted, and also the figure.

The following points call for remark:

(1). The first sentence quoted from the Capture Theory shows that its author entirely misunderstands the object of the discussion he enters at this point. The problem is *not to determine the value of the Jacobian Constant*, because this is given explicitly and very simply by (280), as well as by the equation where it first appears; but the purpose of the investigation is to find the shape of the section of the surfaces of zero relative velocity with the *xy*-plane, *after the value of the Jacobian Constant is given.*

(2). The clause immediately preceding equations (278) has no meaning.

(3). The second equation of (281) should have C' instead of C.

(4). In the first line following (281) $\rho_2^2 + \frac{2}{\rho_2}$ should be written in place of $\rho_2 + \frac{2}{\rho_2}$.

(5). In the third line following (281) it is stated that the roots of the first equation of (281) are real and positive. One

of them is always negative and the other two are real only when a satisfies a certain condition.

(6). Equations (283) are introduced by the words "In this case." They show the turbidity of the thought in this whole matter, for no "case" has been defined for consideration. It is by no means clear that the author of the Capture(d) Theory is aware that he is there imposing the condition that the values of ρ_1 shall all be real so that his results may apply to the physical problem.

(7). In the first line following (283) a should be written in place of a'.

(8). The limit of the inequality of (283) imposes the condition on ρ_2 that all the solutions of the first equation of (281) shall be real, and the *solution* of this limiting relation gives the extreme values of ρ_2 for which the values of ρ_1 are real and positive. But it is necessary also that ρ_2 shall be real and positive, and the condition for this is $a' \leq -3$. The statements in connection with equations (284) in reference to these facts are very vague and uncertain.

(9). The most remarkable misconception of the meaning of what is being appropriated in the part of the one article of the jumbled Capture which has been quoted begins with the second sentence preceding equations (285). There is not so much as a break of a paragraph from what has gone before, and if these statements mean anything they mean that an alternative method of computing ρ_2 is being described. As a matter of fact the equations there reproduced have no such connection with the earlier ones, for they *belong to an entirely different problem*, viz. that of locating the double points of the surfaces. In my Celestial Mechanics, where these equations were first developed, they appear in a separate article (121) with a heading which shows their purpose. Besides this, ρ_2 of (284) is defined by an irreducible cubic and ρ_2 of (285) by an irreducible quintic involving the arbitrary parameter μ. This fact alone would have proved even to a beginner that they are fundamentally distinct, and it should have been sufficient indication of their independence to the author of an "unparalleled series of discoveries" aside from the fact that they occurred in different articles in my book.* While the actual ideas involved abundantly justify the use of the same letter

* "Will any one believe that a modern astronomer can have any real standing who is not a mathematician?" *The Evolution of the Starry Heavens*, by T. J. J. See, POPULAR ASTRONOMY, Nov. 1911, p. 533.

(r_2 in the Celestial Mechanics) in the two places, in the future editions a change will be made so that henceforth those who make books with shears will not be misled on this point. It should be stated that this is by no means the only example of the kind in the Capture Theory.

(10). It will be noticed that, in a general way, the chief difference between Fig. 31 of my Celestial Mechanics and Fig. 19 of the Capture Theory of Cosmical Evolution is that in the former the curves are numbered from the inside out, and in the latter from the outside in; and in the latter *an extra curve* has been added. A little closer inspection will show that in Fig. 19 of the "MAGNIFICENT WORK INDISPENSIBLE TO LIBRARIES" some double lines have been introduced; they are on C_3 on the right and on C_2 on the left. These double lines do not appear in Fig. 31 in my Celestial Mechanics, and they should not appear anywhere as they are an impossibility in the problem. The other figures which have been captured from my Celestial Mechanics are affected by the same "Epoch-Making" originality.

(11). Under Fig. 19 of "The only Great Standard Treatise on Cosmogony ever Published" is the statement that the curves represent the case where the ratio of the masses is about as 4 to 1. This circumstantial detail stimulates in the mind of the reader the inference that the author, who writes as a Professor in the U. S. Navy and supposedly works under the famous code of naval honor, has drawn the figure from actual computations. The inference, however, is incorrect because unfortunately the statement is not true.* The position of the double point on the x-axis to the right of μ belongs to the ratio of masses of about 13 to 1, while the one to the left of $1-\mu$ belongs to a ratio of the masses of about 2 to 1 (more exactly 100 to 47.) There are other equally conclusive evidences that the figure is not based on a computation. The statements under the other figures which have been captured from the Celestial Mechanics are misleading in precisely the same way. In the Celestial Mechanics these figures were drawn from general considerations which do not furnish means for computation; they were intended only to illustrate the rough forms and the

* "Not only must the astronomer be the wisest and intellectually the most penetrating of men, but in order to be a discoverer of the first order, he must be just in his habits of mind and wholly devoted to the truth". *The Evolution of the Starry Heavens*, by T. J. J. See, POPULAR ASTRONOMY, Nov., 1911, p. 534.

evolution of the surfaces. So perfect a reproduction of the erroneous proportions in qualitative figures can not be accidental.

It is clear from the number of errors and misconceptions in the two pages and six lines which have been quoted from The Capture Theory of Cosmical Evolution, that it is impracticable to undertake a careful review of even the three chapters which contain material related to the Jacobian integral.

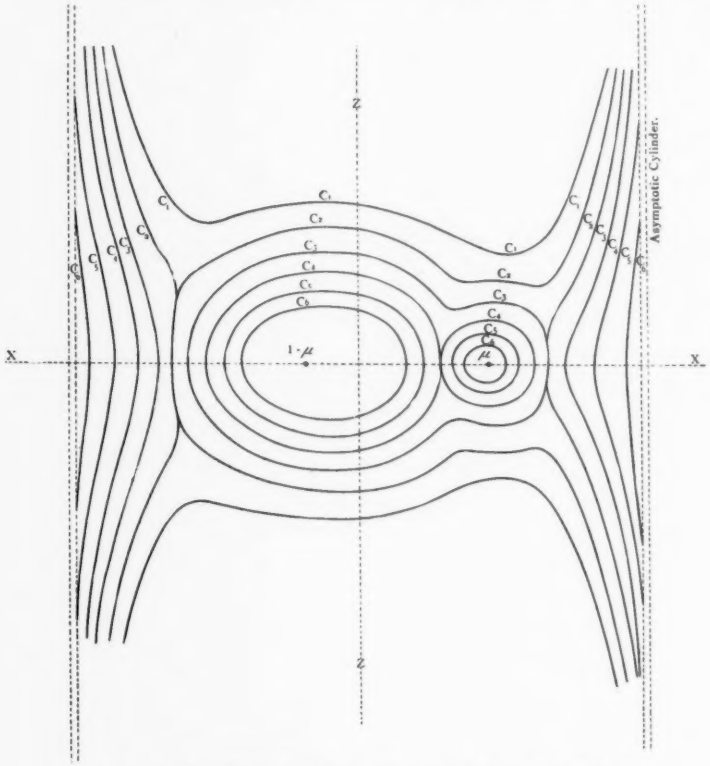


Fig. 19. The Surfaces of Constant Relative Energy as Traced on the xz-Plane, the Ratio of the Masses Being About as 4 to 1.

From the Capture Theory.

Enough has been given, however, to show with what extreme caution one should follow the Capture Theory either in its criticisms or in its "celebrated discoveries."

The distinguished practitioner of the Capture Theory is not altogether negligent of labels and citations, though they are

conspicuously absent in certain directions even in connection with essentials, for the names of Hill, Darwin, and Poincaré have been introduced on every possible occasion. These references are often in relation to mere trivialities, such as a choice of units, and in numerous cases they have been repeated as many times as possible, but such names reflect some glory however slender the connection with them. That the connection

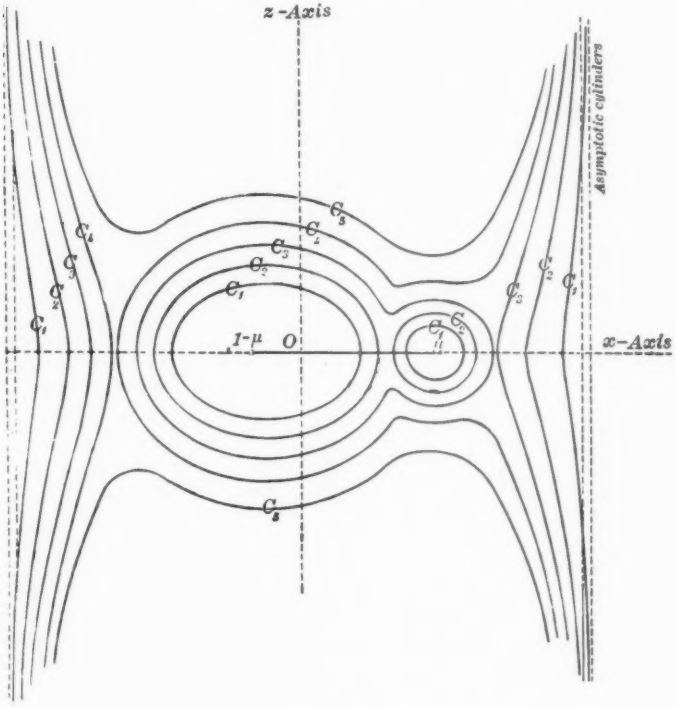


Fig. 31.

From the Celestial Mechanics.

with them in the Capture Theory is excessively slender gradually becomes evident when one tries in vain to discover where its author has made any actual use whatever of those distinctive things which have made these names honored by the whole scientific world, or to find any clear indication that he has any real understanding of them. But regardless of this, he has been able to *prove* the Capture(d) Theory by means of these

names at the various stages of its remarkable history. Just at present they are brought in to support the theory that the solar system has evolved from a spiral nebula, etc., etc., "on the most stupendous scale," but in POPULAR ASTRONOMY, Vol. 14, Nov. (1906), p. 614, at a slightly earlier stage of the "twenty-two years of reflection and professional research,"* we read:

"For a number of years the writer has given consideration to the probable nature of the spiral nebulae, and their importance has been considerably increased by photographs obtained by Roberts and Keeler, and more recently at the Yerkes Observatory. Certain speculations have been indulged in which imply that the spiral nebulae are true nebulae condensing into systems of stars. Though this premature and unauthorized line of thought has been extensively exploited, and even given place in one treatise on Geology, it has always seemed to the writer quite unsound. I have consistently held that so far we do not know the true character of the spiral nebulae, and this position is amply justified by the penetrating remarks of M. Poincaré. ...At present we must frankly admit that the nature of the spiral nebulae is quite unknown....Least of all can we expect any light from the much exploited spiral nebulae, which as M. Poincaré justly remarks, may be other Galaxies. It is time therefore to drop such spirals from our textbooks, or to candidly admit that we are quite in the dark as to their true significance."

Nor must it be supposed that the Capture Theory is at present a fixed rigid thing, for in treating of the revolutions of the planets the resisting material is assumed to affect the planets like a stationary medium, which is a special case of the planetesimal resistance considered by Chamberlin and myself; while, in treating of the rotations of the planets, the demands of the results to be obtained make it necessary to abandon this assumption and to adopt the general planetesimal organization.† The elastic methods of the Capture Theory seem to offer unlimited opportunities for obtaining interesting results.

Now the criticism of the author of the Capture(d) Theory is that I have used the Jacobian integral without taking into account the resisting medium whose existence he has later postulated. A sufficient answer to this is that there is no Jacobian integral when the bodies move in a resisting medium.

---

* Capture Theory, p. 5.

† Compare pp. 545-547 of Nov. 1911 number of POPULAR ASTRONOMY with pp. 70-78, Vol. II, of Chamberlin and Salisbury's Geology, 1906, and articles 374-377 of my Introduction to Astronomy, 1906.

This is the fact notwithstanding the naive arguments to the contrary on p. 224 of the Capture Theory. The only new mathematical result in the three chapters under consideration is "the complete Jacobian Integral" in the case of a resisting medium, equation (276), p. 222:

$$\text{“}x^2+y^2+\frac{2(1-\mu)}{\sqrt{(x-x_1)^2+y^2+z^2}}+\frac{2\mu}{\sqrt{(x-x_2)^2+y^2+z^2}}=C+at;\ (276)\text{”}$$

We remark that the assumption that resistance always reduces the velocity relative to rotating axes (under which the term at is added) because it does with respect to fixed axes, is unsound; that this "integral" does not satisfy the differential equations of motion, a condition which all integrals heretofore have fulfilled; that it is the only known example of a first "integral" of dynamical equations which is independent of the components of the velocity; that its form implies that though the resisting medium retards the wandering embryo satellite it exerts no attraction upon it or upon $1-\mu$ and μ; and that thus it is the only known example of matter having inertia but not gravitative power. If these principles shall be extensively adopted surely this work will constitute an "Epoch-Making New Philosophy of the Physical Universe."

If these things are true it may be asked why Poincaré, Brown and other high authorities are such enthusiastic supporters of the Capture Theory. The first thing is to find the basis for this claim since these astronomers have not announced in their publications that they have taken such a position. The claim seems to have close kinship with those which lie so delicately buried in the statement that "Volume II of Researches on the Evolution of the Stellar Systems will thus occupy in Cosmogony an epoch-making place, something like Copernicus' de Revolutionibus Orbium Coelestium does in Astronomy," and in the modest admission that "We are still dazzled by the splendors of the light which has been suddenly thrown on the invisible processes of creation."*

Since the work of Brown is somewhat related to the Jacobian integral, and since in the November 1911 number of POPULAR ASTRONOMY, p. 544, it is unequivocally claimed that the "Capture Theory of Satellites (is) Independently Confirmed by Brown," while Brown himself in his publications on this subject has remained absolutely silent as to its possible relation to the

* *The Evolution of the Starry Heavens*, by T. J. J. See, POPULAR ASTRONOMY Nov. 1911, p. 531.

Capture Theory, we may consider briefly the facts involved. The results will throw light on what may be expected in all similar claims.

Professor Brown wrote on the subject of tracing a continuous series of periodic orbits with single loops from those which are of the nature of superior planets to those which are of the nature of inferior planets and satellites. The fact that this continuous series exists (and it is "continuous" only in a very limited sense of the term) does not mean that a body originally moving in one of the exterior orbits will run through all of them and finally end by moving in an interior one, any more than the fact that the space between a circle and an elongated ellipse having the same perihelion distance can be filled in with a continuous series of ellipses means that a body originally moving in the elongated ellipse will run through all the intermediate ones and finally move in the circle. On the contrary, it is certain that a satellite could not go through the series of periodic orbits in question, for the relative energy constant has a minimum in the midst of the series. The continuous series does not exist when the relative orbit of the finite bodies is not strictly circular, (and they are not circular in the solar system,) and it is infinitely improbable that a physical body would be so started as to move in one of these periodic orbits at all. And, finally, the fact that *the period is infinite* in three members of the series would be disconcerting to one whose ability in ignoring all difficulties is less remarkable, or whose optimism respecting the value of his own work is less sublime.

The University of Chicago, Dec. 5, 1911.

FLAMSTEED'S NUMBERS AND BAYER'S GREEK LETTERS.

FLORENCE L. BALDWIN.

In the filing of reduction sheets of spectrograms of large numbers of stars, we have found it convenient at the Yerkes Observatory to make use of Flamsteed's numbers as substitutes for or supplementary to Bayer's Greek letters. The number of stars having Greek letters in any constellation is small, and the letters have no relation to the position of the stars. The Flamsteed numbers give the only designation for the fainter

naked-eye stars (except catalogue numbers), and hence must be employed for many stars. Confusion only can result in trying to arrange any extensive program of work on stars by letters and by numbers: by right ascension is the most orderly, as well as the most convenient way. The fact that Flamsteed's numbers are practically in order of right ascension in each constellation makes their use advantageous.

It will be found that this table of equivalents for the Greek letters will also be of service when one is looking for any Greek-letter star in any catalogue or list of stars such as Ambronn's, the "Harvard Revision", or various photometric or spectroscopic lists. In such a constellation as Draco, for instance, one might search through several hours of right ascension before finding the Greek letter, but with the equivalent Flamsteed number the eye will readily pick up other Flamsteed numbers and quickly be brought to the star sought. Thus ζ *Draconis* is seen by the table to have the Flamsteed number 22, with which one readily finds it in any catalogue of the brighter stars.

At the suggestion of Professor Edwin B. Frost this table of equivalents has been arranged from Flamsteed's *British Catalogue* as "corrected and enlarged" by Francis Baily in his "Account of the Rev. John Flamsteed, The First Astronomer-Royal. London, 1835."

Flamsteed's catalogue was first published in Vol. 3 of his *Historia Coelestis Britannica* which appeared in 1725, six years after his death. He was therefore unable to oversee the completion of its printing. From his letters, it is evident that the reduction and publication of his observations were interfered with by his own poor health, by his lack of means to hire adequate computers, and by difficulties in the actual printing, some of which he attributed to Sir Isaac Newton and Edmund Halley.

In some remarks before the Royal Astronomical Society in May 1829 (*Memoirs* **4**, 129, 1830), Baily said:

"Flamsteed's catalogue of stars, the proudest production (considering the period at which it was made) of the Royal Observatory at Greenwich, was deduced from observations made with a mural quadrant, (or rather arc of 120 degrees,) furnished merely with cross-wires in the focus of the telescope, and is a remarkable instance, in common with that of Lacaille, and others even in more recent times, of the great benefit that may be rendered to astronomy by instruments of very moderate capacity, when handled by men of superior talents and skill."

TABLE OF EQUIVALENTS.

	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω
Andromeda	21	43	57	31	30	34	38	24	17	19	16	37	35	46	1	29	27	25	53		42	52	20	48
Aquarius	34	22	48	76	2	55	62	43	33	63	73	6	13	23	31	52	46	57	*	59	90	92	†	‡
Aquila	53	60	50	30	13	17	55	65	41	39	16	38	32	59	54	52	67	44	63	49	61	47	48	25
Aries	13	6	5	57	48	58	17	22	8	12	9	34	32	24	37	42	*	43	†					
Auriga	13	34		33	7	8	10	37	3	44	15	11	32	30	27	35	20	21	29	31	24	25		
Boötes	16	42	27	49	36	30	8	23	21	17	19	51	*	37	35	29	25	28	4	5	54	48	43	41
Cancer	65	17	43	47	41	16	33	31	48	76	19	*	69	77	†	‡	§	‖	72	¶	**	18	††	‡‡
Canis Major	9	2	23	25	21	1	31	14	20	13		18	*	†	‡									
Canis Minor	10	3	4	*	2	13	5																	
Capricornus	*	9	40	49	39	34	22	23	32	43	48	51	8	†	12	10	11	7	‡	15	28	25	16	18
Cassiopeia	18	11	27	37	45	17	24	33		15	14	30	25	19	22	20	7	8	5	*	34	39	36	43
Centaurus								5																
Cepheus	5	8	35	27	23	21	3	2	32	1	22	13	10	17	34	33	29							
Cetus	92	16	86	82	83	55	31	45	8	*	91	87	78	†	68	89	72	76	52	59	‡	53		
Corona	5	3	8	10	13	7	2	4	14	11	12	6	*	19	1	9	15	17	16	18				
Corvus	1	9	4	7	2	5	8																	
	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω

Aquarius: * $69=\tau^1$, $71=\tau^2$. † $91=\psi^1$, $93=\psi^2$, $95=\psi^3$. ‡ $102=\omega^1$, $105=\omega^2$.
Aries: * $44=\rho^1$, $45=\rho^3$, $46=\rho^3$. † $61=\tau^1$, $63=\tau^2$.
Boötes: * $52=\nu^1$, $53=\nu^2$.
Cancer: * $9=\mu^1$, $10=\mu^2$. † $62=o^1$, $63=o^2$. ‡ $81=\pi^1$, $82=\pi^2$. § $53=\rho^1$, $55=\rho^2$, $58=\rho^3$. ‖ $46=\sigma^1$, $57=\sigma^2$, $61=\sigma^3$. ¶ $24=\upsilon^1$, $28=\upsilon^2$, $30=\upsilon^3$.
** $22=\phi^1$, $23=\phi^2$. †† $13=\psi^1$, $14=\psi^2$. ‡‡ $2=\omega^1$, $4=\omega^2$.
Canis Major: * $6=\nu^1$, $7=\nu^2$, $8=\nu^3$. † $4=\xi^1$, $5=\xi^2$. ‡ $16=o^1$, $24=o^2$.
Canis Minor: * $7=\delta^1$, $8=\delta^2$, $9=\delta^3$.
Capricornus: * $5=\alpha^1$, $6=\alpha^2$. † $1=\xi^1$, $2=\xi^2$. ‡ $13=\tau^1$, $14=\tau^2$.
Cassiopeia: * $26=\upsilon^1$, $28=\upsilon^2$.
Cetus: * $96=\kappa^1$, $97=\kappa^2$. † $65=\xi^1$, $73=\xi^2$. ‡ $17=\phi^1$, $19=\phi^2$, $22=\phi^3$, $23=\phi^4$.
Corona: * $20=\nu^1$, $21=\nu^2$.

	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω
Crater	7	11	15	12	14	27	30	21	24	16	13										*			
Cygnus	50	6	37	18	53	64	21	13	*	1	54	78	58	62	†	‡	73	67	65	66	12	17	24	§
Delphinus	9	6	12	11	2	4	3	8	5	7														
Draco	11	23	33	57	63	22	14	13	12	5	1	21	*	32	47	58	67	61	60	52	43	44	†	28
Equuleus	8	10	5	7																				
Eridanus		67	34	23	18	13	3				69	57	48	42	38	26	*		†	‡			65	61
Gemini	66	78	24	55	27	43	7	34	60	77	54	13	18	31	71	80	62	75	46	69	83			42
Hercules	64	27	20	65	58	40	44	91	85	7	76	86	94	92	103	67	75	35	22	6	11	1		24
Hydra	30		46	4	11	16	7	22	35	38	41	42				49	13	5	*	†	‡		45	18
Leo	32	94	41	68	17	36	30	70	78	1	4	24	27	5	14	29	47	77	84	91	74	63	16	2
Lepus	11	9	13	15	2	14	16	18	3	4	6	5	7											
Libra	9	27	38	19	31	*	44	46	†	43	45	7	‡	§	‖									
Lupus			3	2							5													
Lyra	3	10	14	*	4	6	20	21	18	1	15	2	†											
Navis									15					7				1	3					
	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω

Crater: * $1=\phi^2$, $2=\phi^3$.
Cygnus: * $7=\iota^1$, $10=\iota^2$. † $30=o^1$, $31=o^2$. ‡$80=\pi^1$, $81=\pi^2$. § $43=\omega^1$, $45=\omega^2$, $46=\omega^3$.
Draco: * $24=\nu^1$, $25=\nu^2$. † $31=\psi^1$, $34=\psi^2$.
Eridanus: * $8=\rho^1$, $9=\rho^2$, $10=\rho^3$. † $1=\tau^1$, $2=\tau^2$, $11=\tau^3$, $16=\tau^4$, $19=\tau^5$, $27=\tau^6$, $28=\tau^7$, $33=\tau^8$, $36=\tau^9$. ‡ $41=\upsilon^4$, $43=\upsilon^5$, $50=\upsilon^6$, $52=\upsilon^7$.
Hydra: * $31=\tau^1$, $32=\tau^2$. † $39=\upsilon^1$, $40=\upsilon^2$. ‡ $43=\phi^1$.
Libra: * $32=\xi^1$, $33=\xi^2$, $34=\xi^3$, $35=\zeta^4$. † $24=\iota^1$, $25=\iota^2$. ‡ $21=\nu^1$, $22=\nu^2$. § $13=\xi^1$, $15=\xi^2$. ‖ $29=o^1$, $30=o^2$.
Lyra: * $11=\delta^1$, $12=\delta^2$. † $8=\nu^1$, $9=\nu^2$.

	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω
Ophiuchus	55	60	62	1	2	13	35	42	25	27	10	57	64	40			5	49	69	3	8	7	4	9
Orion	58	19	24	34	46	50	28	*	44	53	39	61	67	70	†	‡	17	48	20	36	§	‖	¶	47
Pegasus	54	53	88		8	42	44	26	24	10	47	48	22	46	43	*	50	49	62	68	81	89	84	
Perseus	33	26	23	39	45	44	15	13		27	47	51	41	46	38	22	25	35	18			7	37	28
Pisces	113	4	6	63	71	86	99	10	17	8	18	98	106	111	110	102	93	*	83	90	85	84	†	28
Piscis Aus.	24	17	22	23	18		12	10	9		16	14												
Sagitta	5	6	12	7	4	8	16	17																
Sagittarius			10	19	20	38					22	13	*	†	39	41	‡	34	40	46	27	§	42	58
Scorpius	21	8		7	26						35		14			6	5	20	23			17	15	*
Serpens	24	28	41	13	37	57	58	63	21	35	27	32	53	55	56	44	38	50	*	31		20	23	34
Taurus	87	112	54	*	74	123	25	†	102	‡	35	49	38	2	1	73	86	§	94	‖	52	59	42	¶
Triangulum	2	4	9	8	3																			
Ursa Major	50	48	64	69	77	79	85	25	9	12	33	34	54	53	1	4	8	*	14	29	30	63	52	45
Ursa Minor	1	7	13	23	22	16	21	15																
Virgo	67	5	29	43	47	79	15	51	99	98	100	107	3	2	9	8	30	60	93	*	105	26	40	1
	α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο	π	ρ	σ	τ	υ	φ	χ	ψ	ω

Orion: * 41=θ^1, 43=θ^2. † 4=o^1, 9=o^2. ‡ 1=π, 2=π^2, 3=π^3, 7=π^4, 8=π^5, 10=π^6. § 37=ϕ^1, 40=ϕ^2. ‖ 54=χ^1, 57=χ^2, 64=χ^3, 62=χ^4. ¶ 25=ψ^1, 30=ψ^2.
Pegasus: *27=π^1, 29=π^2.
Pisces: * 69=σ^1, 76=σ^2. † 74=ψ^1, 79=ψ^2, 81=ψ^3.
Sagittarius: * 32=ν^1, 35=ν^2. † 36=ξ^1, 37=ξ^2. ‡ 44=ρ^1, 45=ρ^2. § 47=χ^1, 48=χ^2, 49=χ^3.
Scorpius: * 9=ω^1, 10=ω^2.
Serpens: * 9=τ^1, 12=τ^2, 15=τ^3, 17=τ^4, 18=τ^5, 19=τ^6, 22=τ^7, 26=τ^8.
Taurus: * 61=δ^1, 64=δ^2, 68=δ^3. † 77=θ^1, 78=θ^2. ‡ 65=κ^1, 67=κ^2. § 91=σ^1, 92=σ^2. ‖ 69=υ^1, 72=υ^2. ¶ 43=ω^1, 50=ω^2.
Ursa Major: * 11=σ^1, 13=σ^2.
Virgo: * 102=υ^1, 103=υ^2.

INITIAL DIFFICULTIES IN VARIABLE STAR WORK.

DR. EDWARD GRAY.

(PREFATORY NOTE. This article is addressed to the amateur just beginning systematic observation of variable stars with a telescope lacking circles. It is supplementary and ancillary to the article by Mr. W. T. Olcott in "POPULAR ASTRONOMY" for March, 1911, and has been, in fact, prepared at that gentleman's suggestion.)

Every beginning is difficult, wrote—or quoted—the Roman poet Horace some centuries ago; and the saying remains true to this day. Assuming good eyesight and, especially, freedom from tendency to vertigo on the part of the observer the first difficulties which lie before the tyro, in turning from recreation among the planets and double stars, are two; to understand the Harvard charts sent; and then to locate a faint variable in the sky in the month when the identification is first sought to be made.

First, as to comprehending the charts sent. It will be noticed that the size of these is usually eight by ten inches; and a little attention shows that they are photographic enlargements from some source, which circular 166 tells us is mostly the charts of the Bonn "Durchmusterung" (for the brighter variables); and the scale is 1 mm = 60″. A little study shows that the parallels of declination are always spaced uniformly 2¼ in. (57^{mm}) apart; but that the meridians are sometimes closer, sometimes farther apart, yet that the interval is always 4^{m}. Why four minutes of time? Clearly because 4^{m} correspond to one degree of arc. The average chart thus presents an area of twelve square degrees, but some are smaller.

So far the way is comparatively plain to illation; but now we encounter some unexpected difficulties in the absence of any explanatory text. The lesser is the occurrence on some of the charts of a few stars underlined or overlined with a short dash, or, possibly, two such dashes; this means that the star is a double or triple as the case may be. The next more serious feature relates to the lettering of the stars as *c*. *d*, *e*, *l*, *m*, *n*, *r*, *y*, δ, ϵ, γ, etc. Let not the novice be misled by these. "c" on the chart of R Cygni, for instance, does not mean the Bayer star *c* as shown upon the various star-atlases; so ϵ and γ on the chart of *o* Ceti (Mira) do not mean the stars of those titles upon the atlases; in short these letters were assigned in the Harvard Observatory for their own convenience.

Another difficulty of the contrary kind is that naked-eye stars, for example ι and θ Cygni, are left undesignated. This must be met by a star-atlas or a celestial globe.

The last difficulty is best exemplified by a concrete case. Let us take the two stars T Herculis and R Ophiuchi adduced and mapped in Mr. Olcott's article in the March (1911) issue of "POPULAR ASTRONOMY." T Herculis is designated as 180531; yet on the map its right ascension appears as $18^h\ 3^m\ 30^s$, not $18^h\ 05^m$. With R Ophiuchi the discrepancy is more marked, thus—its Harvard designation is *170215*: yet on the chart it stands in R. A. $16^h\ 55^m$. It means a demonstration of the precession of the equinoxes. Harvard Observatory has been at work a long time upon Variable Stars and these charts register the position of some previous epoch perhaps that of 1850, or 1855.

And now, having acquired a fairly intelligent understanding of our charts, let us turn to the difficulty in manipulating the telescope for finding the variable star. To minimize these manipulative difficulties and particularly to obviate standing in the cold of a winter's night for hours, searching in vain for some elusive star, let us heed Proctor's practical admonition to "not leave to the precious hours of the night the study of the bearing and position of the objects he proposes to examine" and do some preliminary work first, partly desk-work and partly observational. If the observer has not already measured the field of view of his two lower power eyepieces and of the finder, it will repay him, in saving time hereafter, to do so now. Choose an equatorial star for this purpose, such as Delta Ceti or Delta Orionis.

The knowledge thus gained shows you what apparent space one degree occupies in your finder and in your $1\frac{1}{2}''$ or $1''$ ocular; and this measure will be called into constant requisition from the first hour that the finding of a star is attempted. My one and a half inch ocular, for example, has a field of $1\frac{1}{2}°$ diameter. Having found the diameter of the field of the eyepiece which will be most used, let the student cut out from tracing-paper a circle of this size—say one degree in diameter—and apply upon the chart over the variable as a center. This procedure will show, graphically, the field as it will appear in his telescope. It gives precision in knowing what to look for. This principle is recognized in Hagen's Atlas of Variable Stars, where the variable is at the center of a square, $1°$ to each side. The desk work is to the chart what the finder is to the telescope

and consists in making a rough sketch or, better, a tracing, from a star atlas of the neighboring stars which will be used to converge upon the variable and to jot down the approximate distances from three or four of these to the variable. Generalities in such cases are seldom satisfactory to the novice; hence with the editor's forbearance I will adduce a single illustrative example. Chi Cygni lies in the Milky Way in a region rich in stars; how pick it out? It lies between η and ϕ, both naked-eye stars; 3¼° N. E. of ϕ, 2½° S. S. W. of η; 1¼° W. S. W. of 17 and 45′ east of χ^1, the double just visible to the naked eye in clear weather. Now 2½° is just one half the diameter of the field of my finder, hence a convenient measure. χ^1 once brought to the eastern border of the field of the telescope charged with a low-power eyepiece, χ^2 is 45′ west within an irregular quadrilateral figure of stars between the eighth and ninth magnitudes.

Without the Harvard chart and provided only with a rough pencil sketch showing only χ^1 with two faint neighbors on one side and one on the other, all in a curved line, and six stars in the vicinity of χ^2 the writer found this star for the first time in perhaps sixteen minutes' search and was delayed at that because the reference star χ^1 had not been marked a double. χ^2 has a very distinctive color.

Each observer must work out for himself a system for identifying the variable; but the process will be by alignment, triangulation, or both combined, starting from some known or visible star not too distant. He, however, who has measured the diameter of the field of view which he is employing and can visually estimate two degrees, one degree, one half a degree, will have a sense of self-reliance and surety which must be painfully absent from the one who goes floundering around.

Having now the sketch, with measures, and the appropriate Harvard Chart, the recruit may take them to the telesocpe and set out to capture the star desired. In doing this the position, in the sky, of the constellation, at the time of observation, must receive due attention, particularly if it be circumpolar. The principle is stated by Mr. Olcott in these words: "When the field is rising in the east the north point should be at the right hand; when setting, at the left. This is a point which may cause a little confusion at the start." Let me present the subject in another way. The maps are all drawn to R. A. and Declination; the telescopist's problem is to convert these coördinates, visually, into altitude and azimuth. The

celestial globe furnishes by far the readiest and simplest mode of doing this. Byrd's Laboratory Manual in Astronomy gives a method for doing this on p. 84 and trigonometrical formulae for checking the result pp. 85 to 87.

Let the observer compare the very different aspect in the sky of the constellations Hercules and Cygnus, for example, in spring, summer and autumn. Comparing the part of the constellation to be studied with the chart he must make the latter's meridians point to the north pole at every season and so get his bearing for the particular evening. It is an exercise in translating from terms of the Equator system into those of Horizon system. (Todd).

If the novice finds identification difficult—as may well happen—let him remember that nothing worth while comes without effort; and try again, perhaps making a more close estimate of the bearings of his guiding stars.

Having at last really found the variable, and experienced the joy thereat, there remains only the visual estimate and recording it.

As to the record I would suggest the adoption of index-cards, or perhaps more convenient, a loose-leaf note-book 4 x 6 inches in size, such as the "Klik" 420 of the Saugerties (N.Y.) M'f'g. Co. A continuous record can thus be kept of each star and the indexing is a small matter. But—whatever kind of record is kept—the notebook must not be taken to the telescope or even to the observatory, in order to avoid a bias of the owner's mind as to what magnitude any star should be expected to show on the evening of observation. For this reason also it is desirable to have a number of variable stars to watch, a dozen or more, so that the observer shall not constantly be remembering the last estimate of the star or stars which he plans to estimate the present evening.

A difficulty which will arise comparatively early but which is not properly initial presents itself in estimating the light-value of red stars particularly when near a brighter white star. This is more important than appears at first sight and a brief paragraph upon it will be presented in the early future.

"AN APPEAL TO THE FRIENDS OF ASTRONOMY."

In 1844; there appeared in Schumacher's Astronomical Year Book an article by Fr. Argelander, called "An Appeal to the Friends of Astronomy for the making of certain interesting and useful, as well as easily conducted, observations in various branches of heavenly knowledge." The Northern Light, the Zodiacal Light, Shooting Stars, the Twilight, the Milky Way, the Magnitudes and Colors of Stars, are discussed in turn, but the last chapter, which is on the Variable Stars, is the longest and most earnest. In it Argelander seems to speak from the heart, and his enthusiasm and sometimes flowery language reveal to us another side of the author of the Bonn Durchmusterung. After reading the article, one feels like reviewing the advances in our knowledge of the variable stars since 1844. Instead of 18 variables, as in Argelander's catalogue, we must provide for more than 4000. Instead of observers in "Aachen, Breslau, and in Bonn," they are found in nearly every country of Europe, in nearly all of the United States, in Japan, in South America, in Australia, in Egypt, and in South Africa. The investigations are, indeed, "no longer isolated!" Argelander's interest was communicated to his pupils, Schönfeld, Schmidt, and Gould, and his zeal has been continued by Pickering,, who has made the investigations of the variable stars one of the large problems of the Harvard College Observatory

ANNIE J. CANNON.

Harvard College Observatory, Cambridge, Mass.
December 2, 1911.

THE VARIABLE STARS.

FR. ARGELANDER.

Translated from the German by Annie J. Cannon.

The Greek and Roman writers and the Chronicles of the Middle Ages often mention new stars bursting forth, and it was sometimes added that after they shone for a period, they again became invisible. The most marvelous of these stars was the one which appeared in Cassiopeia, the last of October or the first of November, 1572, suddenly before the eyes of the astonished astronomers. It was as bright as Venus at its first appearance, but gradually became fainter, and disappeared in March, 1574. If we were inclined to regard the tales of the

chroniclers of new stars as fables or errors, this was an apparition which proved the doubtful fact. And not alone for the contemporaries was this demonstrated; for so many precise descriptions and observations were gathered together in a Memoir by the distinguished astronomer, Tycho Brahé, the careful and expert observer of this phenomenon, that this remarkable appearance stands forth as an undisputed fact.

For a similar phenomenon did David Fabricius, pastor in Osteel in Ostfriesland, and previously pupil and assistant of Tycho's, consider a star of the third magnitude, which he saw in the early morning of August 13, 1596, one which he had never seen before, which he could not find in any catalogue, and which he could not again see after October of that year. When the star became very faint, and at last completely disappeared, Fabricius probably thought he had observed a new star. It is especially inconceivable why de did not make known this important observation sooner, why, above all, it aroused almost no sensation, and we find the first scanty mention of it eight years later in two letters of Kepler. It was soon completely forgotten, and when Phocylides Holwarda, Professor in Franecker, in December of the year 1638, while observing a total eclipse of the moon, became aware of a new star in the breast of the whale, saw it increase to the third magnitude, then in January of the following year saw it decreasing, could barely glimpse it in the next August, but in December could plainly see it again, and made his observations known in print,—then they remembered the star of Fabricius, and they found that both stood in one and the same place in the heavens, also the same place in which Bayer in his chart gave a star, but only of the fourth magnitude, which he designated by the letter o. So it was first known that a star became visible from time to time, and even in variable magnitude, between which time, it was invisible, not only to the naked eye, but also in telescopes. Notwithstanding the fact that these appearances were so remarkable, yet they were observed only very incompletely by Fullenius, a colleague of Holwarda, by Jung in Hamburg, and Hevelius in Danzig. In 1660, however, Hevelius and, after him, some French astronomers, began to follow the star industriously. Bouillaud first noticed that the light changes of this wonderful star, which Hevel called Mira, had a somewhat regular period, and that within about eleven months, the star gradually decreases from its greatest brightness, remains invisible several months, and then anew gradu-

ally reaches its greatest brightness. He, and especially later, Jacob Cassini, pointed out that neither is the period wholly regular, nor does the star reach the same magnitude at different maxima, for sometimes it reaches the second magnitude, and at other appearances, it halts between the third and fourth. But upon precise, daily conducted observations, or upon a consistent carrying out of any given method, in order to determine more surely the course of the light changes, no man thought.

No change in this heedlessness was made by the discovery of two new periodically variable stars, the star χ in the throat of the swan, by Gottfried Kirche in the year 1686, and one in Aquarius, No. 30 (R Aquarii) in Hevel's star catalogue, by Maraldi in the year 1704, nor even by the discovery about this time by Montanari and Maraldi, that the star Algol, or β in Perseus, at different times appeared to be of different magnitude. Meanwhile, men contented themselves to observe these stars at intervals of months, or even years, to specify their approximate magnitudes and from such observations, to deduce a rough period.

First about the end of the past century, there arose again somewhat more interest upon this subject, and there were two English astronomers, John Goodricke and Edward Pigott, who not only carefully observed the known variables, discovered the periodicity of Algol, and determined that of the others more precisely, but also greatly increased their numbers, by finding η Aquilae, β Lyræ, δ Cephei, a small star in the northern crown (R Coronae Borealis) and a similar one in Sobieschi's Shield, (R Scuti) to be periodically variable. Then the elder Herschel appeared, who discovered a periodic variability in α Herculis, also Koch in Danzig, who did the same for a star in the Lion, No. 420 in Mayer's Catalogue (R Leonis). Later, Harding discovered new variable stars in Virgo, in Aquarius, and in the serpent of Ophiuchus. Bode, Olbers, and especially Wurm, busied themselves with this class of phenomena. The latter must have made many and probably good observations, but to the great loss of the subject, they were never made known, and have probably become wholly lost. For Wurm contented himself with publishing the results which he derived with great precision from his own observation and those of his predecessors, concerning the period and the former appearances of Algol, η Aquila, Mira and the variables in Virgo. χ Cygni found an equally carefully investigator in Olbers, whose second memoir on

this subject appeared after his death in this Year Book for 1841.

After a long interval, Westphal in Danzig took up variable stars, and between 1817 and 1819, observed all the known variables and reckoned their periods by correct methods. Unfortunately, however, his industry decreased, and soon his ardor completely cooled, and again the variables were left for many years in total oblivion. Now at the present time, they are finding new friends, who are striving to increase our knowledge of them. Sir John Herschel has in the southern hemisphere proved a remarkable variability in η Carinae, although almost no details are yet communicated, but whose periodicity has been made very probable by observations from another side. The same has also discovered the variability of α Cassiopeiae, α Orionis and α Hydrae, the last being somewhat doubtful. A couple of English lovers of Astronomy have joined the ranks, and in Germany the appearances are now generally followed with care and continuity in Aachen by Principal Heis, in Breslau by Professor von Boguslawski, and in Bonn. May these investigations no longer be isolated! May these pages be the means of securing a goodly number of earnest, pains-taking participants!

The following table gives a list of all stars known to be certainly variable which are visible in our neighborhood. It contains also those which are never visible to the naked eye, and therefore lie primarily without the province of this article. I have thought perhaps many amateurs, who have interest in this marvelous class of stars, might wish to purchase a telescope, by which they could follow the changes of those stars only visible in that way. The first column contains the number of the star in the order of its being known as periodically variable; the second, the constellation in which it occurs, and the designation in the same, if there be such; the third and fourth, the Right Ascension and Declination for the year 1840; the fifth, the mean duration of the period in days and decimals, the number of decimal places depending upon the precision with which the period is known; the sixth and seventh, the magnitude which the star has in maximum and in minimum, a dash in the last column meaning that the star in its least brightness either completely disappears, or at least has not up to this time been seen with certainty. The surest facts are here used for a foundation and additional information will follow later on for the explanation of the peculiarities of the various stars. In the case of α Aquarii, the period is still very uncertain and therefore it is marked with a question.

	Name of the star.	1840 AR.		Decl.		Length of the Period	Magnitude Max.	Min.
		°	′	°	′	d		
1	o Whale	32	49	− 3	42	332.04	2.	—
2	χ Swan	296	6	+32	31	406.06	5.	—
3	30 Snake	200	15	−22	27	493.86	4.	—
4	Algol	44	26	+40	20	2.8673	2.3	4
5	η Eagle	296	5	+ 0	36	7.1763	4.3	5.4
6	β Harp	281	3	+33	11	12.9119	3.4	4.5
7	In the Lion	144	44	+12	10	311.4	5.6	—
8	δ Cepheus	335	48	+57	35	5.3664	4.3	5.4
9	α Hercules	256	50	+14	35	95	3	4.3
10	In the Crown	235	30	+28	41	335	6	—
11	In Sob. Shield	279	44	− 5	52	60.395	5	7
12	In the Virgin	187	36	+ 7	52	145.43	6	—
13	In the Watercarrier	353	53	−16	10	389	7	—
14	In the Serpent	228	33	+14	54	366	8	—
15	Ditto	235	50	+15	38	359	6.7	—
16	α Cassiopeia	7	52	+55	39	79.03	2	3.2
17	α Orion	86	38	+ 7	22	199	1	1.2
18	α Snake	139	56	− 7	58	55?	2	2.3

Mean periods and magnitudes are given in the table. As we have already remarked about Mira, so it has been found later of several other variables, that they do not always have the same magnitude at maximum, neither is the length of the period always the same. The differences are very important, the range in light interval being two magnitudes, in the length of period, about one tenth of the same. Also, change has been found the form of the light curve of several stars. In general, it has been observed that most variables increase considerably faster from minimum to maximum, than they decrease again, but neither is the manner in which this occurs, nor the difference between the time of light increase and decrease in all cases constant, but sometimes less, sometimes greater. Much may be ascribed to the lack of precision and small number of observations, but in many cases the irregularities are so marked and the differences in time so great, that they can not be ascribed to these causes alone.

All these circumstances are as yet only slightly investigated. For a few stars indeed, Pigott and Goodricke have given approximately the length of time which they remain in minimum, increase in light, shine in greatest brightness and again decrease. Following them, Westphal has determined in a rough way, for other stars, the times which are occupied by the increase from a certain magnitude to maximum and by the decrease from maximum back to that magnitude. However, all the statements are so vague that they give no definite idea of the various light curves, and still less do they give us any knowledge of the magnitude and form of the deviation from

the rule. Even the knowledge of three of these stars whose periods are completed in a few days, and which have been carefully observed during the last years at Aachen and Bonn in all points of their light changes, is still very limited. If the facts given in the table in general hold good, so that we are able to predict the magnitudes that any of these stars will have any given time, just as we can learn it by the eye through a single observation, then we are concerned only about the mean brightness in the different stages. Whether this is always the same, or subject to fluctuations, which a single observation does not show, but which would only appear from more contemporary observations by different observers, we are still in the dark. This table, moreover, holds only for the immediate present and does not appear to represent, within the errors of observation, those observations made before a half or even before a quarter of a century ago.

On account of the low state of our knowledge of these stars, nothing in general can at present be offered nor, by any means, can a definite theory be given, which can refer the light changes to any one cause. But happily, hypotheses, even if full of error, fail us not. Omitting those which at first glance are seen to be untenable, they resolve themselves into the following three.

(1) Revolution of the stars on their axes, their surfaces being of different luminosity on the different sides, whereby they would be brighter if they turned towards us the side of greatest illumination, on conversely, darker, if the side of less illumination.

(2) Revolution on their axes, with strongly compressed figure, and considerable variation of angle of the axis of rotation towards the line of sight. If the axis nearly coincides with the line of sight, then the stars turn towards us a very extensive surface, send us much more light, and therefore shine brighter than if they, because of a very large angle, turn their edge, if I may so call it.

(3) Huge planets revolving around the stars, in the plane of whose orbits the line of sight nearly falls and which, therethere-fore, by inferior conjunction with the star, cut off a large part of the light formerly coming from it to us, so that it seems less bright.

The first of these hypothesis seems to be the most plausible and, in general, to explain observed appearances of several of the stars, if we assume that the constitution of these stars

is similar to that of our Sun. According to the investigations of W. Herschel, Schröter, Sömmering and others, the Sun is a dark body, covered with great unevenness, which in some portions, especially in the neighborhood of the equator, appears as widely extended mountain chains with very high peaks. A luminous atmosphere surrounds it, perhaps over another not glowing, but only faintly illuminated through the first. The last is of no significance to us, but the luminous one, like that surrounding our earth, undergoes considerable vibrations, which are sometimes so strong that it is forced by that means under the highest peaks, so that it makes these visible as dark spots.

If we assume the same conditions for the variable stars, we must presuppose that in certain regions on them, there are elevations so high and widely spread out that they always tower above the glowing atmosphere. If then, by revolution on its axis, the star turns to us the side on which such elevations are found either wholly or in great numbers, and on which therefore its shining surface is considerably smaller, than on the other, it will appear darker than if it turns to us the side on which there are none, or fewer, and smaller elevations. For the light change of each particular star, we can easily conceive of such an arrangement of numerous, dark, places which will completely explain all phases, especially if we consider that the spots only appear in their full magnitude if they are situated exactly in the middle of the star, or that, on the other hand, they are the less extended the more we look upon them sideways as they approach the edge by revolution on the axis.

In the case of certain stars, with regular periods, which always show the same brightness in similar portions of the period, we conclude from this uniformity, that either the fluctuations of the atmosphere are very slight upon them, or that the elevations consist of either a multitude of precipitous peaks, or a rugged rising plateau, so that the atmosphere even by considerable vibration, covers only more or less restricted regions. But if the stars show very striking differences in their periods and brightness—and it is remarkable that where both appearances occur they always take place together,—then we must conclude that there is upon them a very gentle and gradual rise of the mountain chains. Under this hypothesis, the luminous atmosphere because of small elevations, would cover a greater part of the dark body, and let the star thereby shine much brighter than when because of direct situation in our line

of sight, it has a somewhat lower position, so that a widely extended portion of the dark body lies bare, whereby showing the star considerably fainter.

What can be only briefly indicated here, one can easily work out to the smallest detail for each individual star. It would not be difficult to adjust the probable extension and position of the dark heights to the light change, by means of the greater or smaller deviation of the period and brightness, to estimate approximately, the angle of slope of the mountains, and even with some imagination to determine the kind of mountains by which each star is specially characterized, if we will compare them with those of our earth. But far be it from us, to yield to a play of the imagination which would interfere with earnest investigation. And, moreover, it is not yet time, for there are several very significant difficulties against this hypothesis, of which I will name the most important.

(1) Algol shines during about seven-eighths of the length of its period in wholly normal light, and shows only in the last eighth any certain decrease and increase, an appearance which, on this hypothesis, could hardly be otherwise explained, than on the improbable supposition that simultaneous with the period of rotation on the axis there is a periodic, sudden, sinking of the atmosphere.

(2) It has been already noticed, that most of the variables increase faster in brightness than they decrease. The few for which this fact is not established, are generally not accurately enough known to be able to decide with certainty concerning this, and No. 11 (R Scuti) for which the opposite appears to be the case, is only very approximately determined. Moreover, those that are precisely investigated have the common property that their light decrease at first takes place rapidly, then during a short period is quite unnoticeable, and to the naked eye, appears to stand still, but towards the minimum again becomes more rapid. In the case of β Lyræ, this apparent stillstand changes into a secondary maximum. Both of these phenomena could undoubtedly be explained for each particular star by the special configuration of the elevations, but their concurrence calls for a uniformity of this configuration on all of the variable stars, which we are not authorized to assume, because of the extraordinary variety which everywhere prevails in nature.

(3) In the case of the two variables, a regular change in the period is shown with great probability, namely, for Algol a

very slow decrease, proportional to the time, for β Lyrae an increase probably more rapid and also proportional to the time. In our solar system, the rotations of all the axes are wholly uniform, and Laplace has shown, that according to Newton's gravitation theory, no deviations from this uniformity are possible, which would be observable even after thousands of years. Doubtless, we are not authorized to infer from our law directly as to the laws which rule the other suns, but we have sufficient evidence that also in every distant region, the law of universal gravitation holds good, or at least it is only with the greatest precaution that we should put forward hypotheses, which contradict this; as would be done by assuming that in a short interval of 50 years, already noticeable deviations from the uniformity of the revolution of the axes have occurred.

To be Continued.

A MODERN LOOK AT THE UNIVERSE.

HENRY OLERICH.

Continued from page 30.

Evolution of Moons.

There are at present twenty-six known moons or satellites in our solar system, of which the earth has one, Mars two, Jupiter eight, Saturn ten and an unbroken ring, Uranus four, and Neptune one.

According to the Nebular Hypothesis, all the moons evolved out of broad, highly-heated rings shed from the rapidly rotating planets in the same manner as the planets evolved out of rings shed from a rotating sun.

As we have seen, at first the planets were highly heated and, therefore, very large in volume. The molecules, atoms, and electrons were then kept far apart by the intense heat, but as the heat slowly radiated into space, the planets correspondingly contracted in volume, and this contraction ever increased their rotary velocity, so that eventually the centrifugal force out balanced gravity, and then a broad, highly heated ring was shed by the revolving planet out of which the moon or moons of that planet were slowly built.

Let us notice that the planets which have the least density and which rotate fastest on their axes have the largest number of moons. For instance, the large planet Jupiter completes a rotation in about ten hours, that is, it has a day about ten

FIGURE 14.

The solar system with one sun, one planet, and a ring for Neptune's moon. The unequal density in the various parts of the ring will cause it to break up into masses, and then gravitate into one spherical rotating moon.

hours long, and has eight moons. Saturn is nearly as large and rotates in about the same time as Jupiter, has ten moons and an unbroken ring, all of which seem to be a strong confirmation of the ring-theory as suggested by the Nebular Hypothesis; while our earth, rotating once in twenty-four hours, has but one moon.

WHY THE EARTH AND OTHER PLANETS ROTATE ON THEIR AXES.

By the foregoing explanations, I trust we shall now be prepared to understand quite readily how planets and moons acquire their initial rotary motion, and why that motion ever continues to increase to such a velocity that most of the planets shed one or more rings out of which moons were formed in the same manner as the sun shed the solar rings out of which the planets were formed.

We have seen that a body which does not at all rotate on its axis can never of itself acquire a rotary motion by the process of contraction. Contraction and rotation must, therefore, go together in order to increase the rotary velocity of a rotating

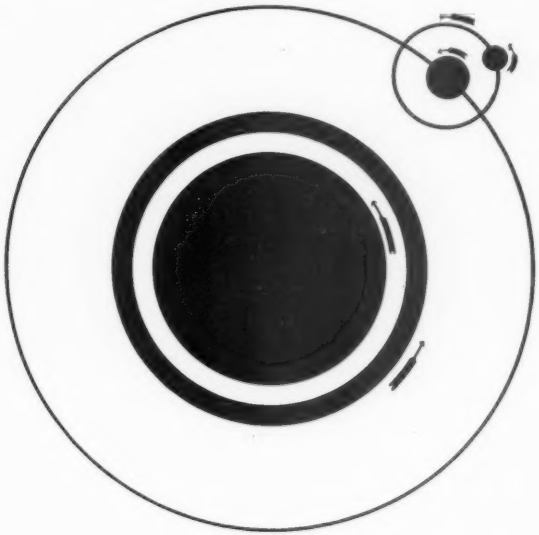


FIGURE 15.

The solar system with one sun, one planet, one moon, and one new ring for another planet, and so the evolution of planets and moons. continues.

body. Now we shall endeavor to elucidate that every planet and every satellite that was formed out of a broad, concentrated ring revolving around its primary, must carry within itself an initial rotary motion, caused by the unequal angular velocity of the particles composing the inner and the outer portions of the revolving ring.

To illustrate this principal pictorially, let the accompanying illustration, Fig. 16, represent a broad, highly-heated, gaseous ring, rapidly revolving around the parent sun. The two small, dark circles, A and B, one at the outer and the other at the inner edge of the broad ring, each represent a particle of matter, completing a revolution around the sun in substantially the same time; but as the outer particle revolves in a much larger orbit, it has, therefore, almost double the angular velocity that the inner one has.

But now by reason of radiating its heat, the broad, nebulous ring begins to contract, and this brings the rapidly-revolving and the slowly revolving particles continually closer together. But in accordance with the FIRST LAW OF MOTION, the

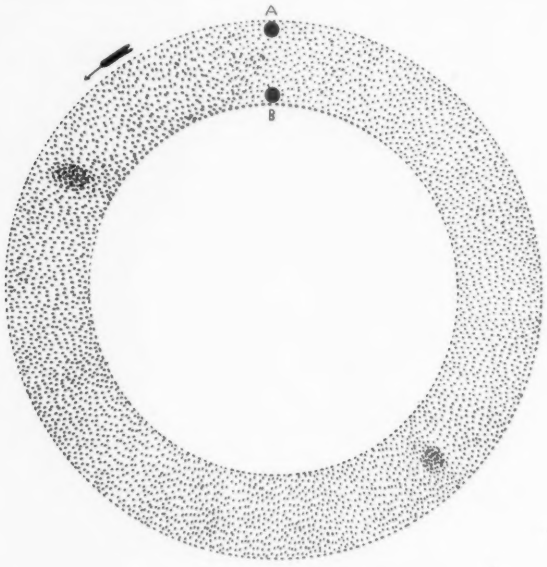


FIGURE 16.

A broad, highly-heated, nebulous ring revolving around the sun (sun omitted.) The two small dark circles A and B represent particles of revolving matter, both particles completing a revolution around the sun in substantially the same time; but the outer particle has a much greater orbital velocity, because it revolves in a much larger orbit. As contraction draws them continually closer together, the outer fast particle is then obliged to rotate around the inner slow one in order that each may continue unabated its initial velocity in accordance with the first law of motion. This unequal velocity of particles, therefore causes the axial rotation of planets and moons evolved out of revolving rings. These rotating principles are experimentally verified by the "Planetary Rotating Machine."

inner one cannot augment its angular velocity, nor can the outer one diminish it; so when the fast and the slow particles, forming the outer and the inner edges of the revolving ring are drawn closer together by gravity, forming parts of one concentrated planetary sphere, the fast particles originally forming the outer edge of the ring, in order to continue their uniform

initial velocity in compliance with the First Law of Motion, are obliged to rotate "around" the slower ones composing the inner edge of the ring, which is now in the form of a spherical planet; and so with all the other particles forming the intermediate portions of the revolving ring, they are now respectively composing the rotating planet or moon; the inner slow particles at the center of the sphere and the outer fast ones at the surface.

This unequal angular velocity of particles composing the various parts of the revolving ring is, therefore, the mechanical cause of planetary and satellitious rotation, and the maximum velocity of the axial rotation depends on the comparative width of the original ring, and the present diameter of the developed planet or moon. That is, if a very wide ring concentrates into a small planet, the planet will rotate rapidly. On the other hand, if a narrow ring forms into a comparatively large planet, the planet will have a long day; that is, it will rotate on its axis slowly.

The Planetary Rotating Machine.

In order to verify the foregoing principles of planetary rotation, the writer succeeded in designing and constructing a mechanical invention that admirably illustrates the rotating ring theory by practical experiment.

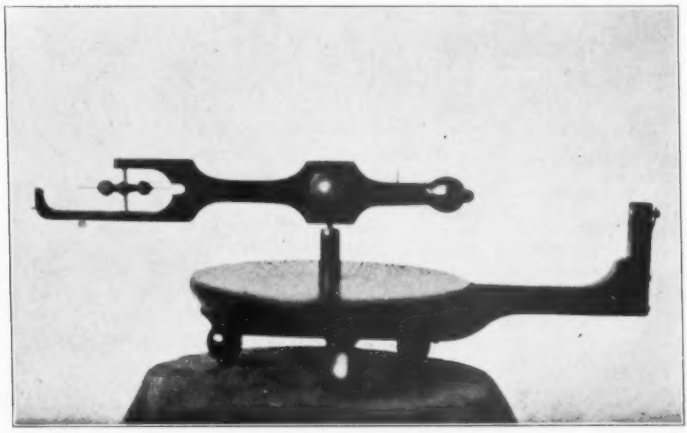


Figure 17.

Photographic view of "Planetary Rotating machine." The arm revolves right or left, and the earth or other planets rotate accordingly

As the reader may see by examining the accompanying drawing and photographic view Nos. 17 and 18, the principal features of the new invention are: 1. A tripod supporting the operating machinery. 2. A revolving arm representing the sun near the pivotal end of the arm, and two small lead balls representing particles of matter in a contracting ring or rotating sphere at the outer end of the arm. One of the balls represents an outer fast particle, and the other an inner slow particle of the revolving ring or planet. 3. A trigger which serves to set the expanded balls free to be drawn nearer together (to contract) by means of two tiny rubber bands when the arm is revolving, the same as the earth and other planets revolve around the sun, and the moons around the planets.

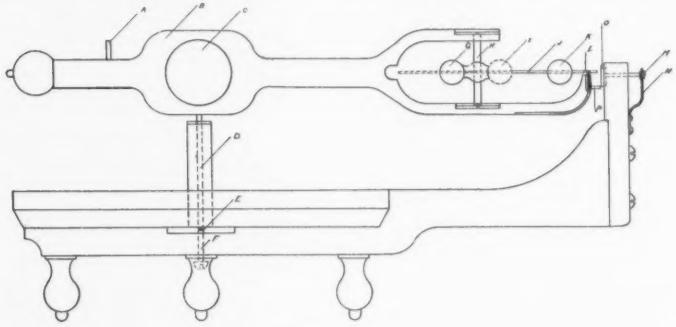


FIGURE 18.

A Arm revolving. *B* Revolving arm. *C* Sun. *D* Arm shaft. *E* Shaft pivot. *F* Adjusting screw. *G* Inside or slow ball. *H* Rotating shaft or earth's axis, *I* Outside or fast ball after rubber strings have drawn it in balance with inside ball. *J* Shaft on which ball *K* slides back and forth from *I* to *K*. *L* Notch in sliding shaft that hooks in latch *P*. *P* Latch on which trigger *O* operates to set free the ball *K* when the arm *B* is revolving. *M* Trigger shaft which pushes onto latch *P*. *N* Trigger shaft spring.

When the arm revolves, the suspended ball *K* has a much greater orbital velocity than the ball *G*, because it revolves in a much larger orbit; and when set free, the rubber strings which represent Gravitation draw it to *I*. It then revolves in a smaller orbit than it did at *K*; but according to the First Law of Motion it must continue its initial velocity, and in order to do this it has to rotate "around" *G* on the shaft *H* which represents the earth's axis.

If the balls, by means of the rubber bands, are drawn closer together when the arm is revolving, the two little balls representing particles of matter, one at the outer and the other at the inner border of the revolving ring, immediately begin to rotate on their common axis, because the outer ball had a

much greater angular or orbital velocity than the inner ball had, and the number of rotations they make during one revolution of the arm depends on the comparative width of the original ring when at its maximum width, and the distance the little balls are still apart after they are drawn toward each other by the tiny rubber bands that represent gravity. The number of rotations during one revolution are the same whether the arm moves rapidly or slowly. This experiment also nicely accounts for the phenomenon that the rotary velocity of some planets is much greater than that of others.

For instance, Jupiter the largest planet of our solar system, having a diameter about ten times that of the earth, completes a rotation in a little over ten hours, while the earth requires twenty-four hours. Other things equal, this indicates that the ring out of which Jupiter was formed originally had an enormous width as compared with the present diameter of that planet, and also as compared with the relative size of the earth, and the original ring of which it was formed.

We can readily understand why a revolving ring will, in obedience to mechanical laws, form itself into a spherical planet or moon, rotating on its axis with continually increasing rotary velocity, and in the same direction as its primary from which it was detached, so that eventually a ring would also be shed from this large, newly-formed, highly-heated, gaseous planet from which a moon or satellite was formed in the same manner and by the same mechanical laws as the planet was formed out of the solar ring. As the contraction and consequent increasing rotary velocity of the sun and planets thus continued, ring after ring was at long intervals shed, from which all the planets and moons of our solar system were consecutively formed; and the same laws, no doubt, apply to all other suns of the universe that may be evolving solar systems of their own.

The illustrations are intended as mere outline sketches, aiding the reader by the help of the eye to get a clearer and easier conception of the gradual evolution of our solar system from a glowing nebula to its present complex form and function as connectedly pointed out in this brief epitome of nebular hypothesis.

Vastness of the Universe.

In order to get at least a faint conception of the infinite vastness of the Universe, let us here make a few comparisons. Light travels with the velocity of about 190,000 miles per

second. It requires only a little over eight minutes for a ray of light to come from the sun to the earth; and a little less than four hours to travel across the intervening space between the sun and Neptune, the outermost planet of our solar system; or it would require about 300 years for a cannon ball at ordinary velocity to pass from the sun to Neptune. Immense as this magnitude of our solar system is, it shrinks into a mere point, when compared with the Universe at large.

A ray of light from the nearest so-called fixed star has to travel over four years before it reaches our little earth. Astronomers estimate that it would require not less than 9,000 years for a ray of light to travel around the circumference of that group of stars known as the Galaxy or Milky Way, of which our own sun and solar system is a part. Vast as this group is, it is still infinitesimally small as compared with what seems to lie beyond. It has been estimated that by the aid of the spectroscope, the photographic plate, and the modern telescope groups of stars and immense nebulæ so distant in the depths of space are revealed to us that a ray of light from them requires more than a hundred million years to reach our earth.

Still there seems to be no apparent end or limit. The more the telescope is enlarged, the more new distant realms spring into view. In this manner, does the modern telescope give us at least some faint glimpses of the infinite vastness of the Universe, the same as the modern microscope reveals some glimpses of the infinite minuteness of the Universe. It is true that we are still continually improving our instruments of research and developing our powers of observation, yet for all of that, it seems highly probable that the ultimate limit of neither the infinite vastness nor the infinite minuteness will ever be brought within the scrutinizing gaze of man. Pascal, the eminent French Astronomer, says, "The Universe is a great circle whose center is everywhere and whose circumference is nowhere."

Geological and Biological Confirmations.

There are also a vast array of Geological and Biological facts in support of the Astronomical and Cyclical Evolution of our solar system according to the theory of the Nebular Hypothesis so far as that theory covers the supposed recurring cycles of integration and the opposite period of disintegration as suggested in the preceding topics.

As conspicuous geologic evidence in support of the Nebular Hypothesis, we have the familiar igneous and aqueous characteristics of our earth and moon, and also that of a number of other planets and moons. Geologists have ascertained that the

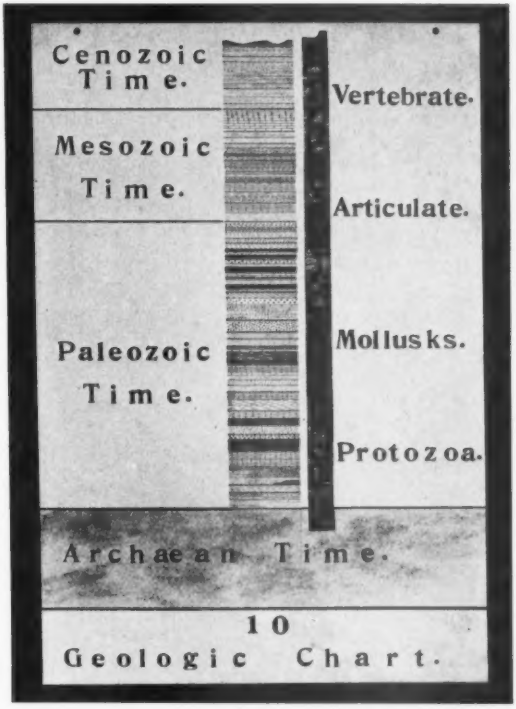


FIGURE 19.

Geologists have found that our earth is covered with layers of stratified rock about twenty miles thick, and a hundred and thirty million years in formation. The simplest fossils are found in the lowest strata, and as we ascend toward the surface, they become more and more complex. A vertical column twenty miles thick with the corresponding fossil remains is here shown.

earth is covered with stratified layer of sedimentary rocks about twenty miles in thickness, and that the time required for their formation is at least a hundred and thirty million years; and under these layers of stratified rocks is a thick bed of mostly igneous rocks of which no one knows the thickness, nor the length of the immense period of time, perhaps hundreds of millions of years, required for its formation.

Imbedded in these layers of sedimentary rocks, paleontologists find fossiliferous remains of the planets and animals that lived and died during these immense periods of Geologic Times. They find the first and simplest remnants of life in the lowest strata, and as we ascend toward the surface through the twenty miles of stratified rock, we meet with fossils indicating a gradually ascending scale of life, culminating with man himself as the superlative triumph of physical and mental organization and development.

To cite only one example of the gradual development of life on earth, we may take the case of the horse. Our present horse has been traced down by its fossils until its size is no larger than a fox; and instead of having one toe or hoof as now, the fossils of the primitive geologic horse show first five toes, then four, and so on down to one. And so the fossils everywhere indicate a slow but gradual variation and modification of individuals and of species.

Professor P. Lowell says: "Spontaneous variation is the motive principle of life, and there is now no more reason to doubt that planets grew out of chemical affinity than to doubt that stones did. Spontaneous generation is as certain as spontaneous variation, of which it is in fact only an expression."

But all this has been clearly and elaborately treated by our modern philosophers and scientists; such as, Spencer, Darwin, Burbank, Haeckel, Buchner, Huxley, Edison, Tyndall, Wallace, Dana, Shaler, and scores of others, so that I need not use my limited time here for pointing out at length this unity, continuity, and ceaseless activity of nature, which, in a limited way, we may daily notice going on around us.

To be Continued.

KING SIRIUS.

CHARLES NEVERS HOLMES.

When royal Rigel glitters like a gem
    Where gleams Orion's glory in the sky
And Queen Capella like a diadem
    Reigns o'er Auriga with a watchful eye;
When winters thraldom rests on vale and hill,
    And skies are clear, and stars shine coldly bright,
Ere most men dream or city's voice is still,
    King Sirius again adorns the night.

PLANET NOTES FOR MARCH, 1912.

C. H. GINGRICH.

The sun will move northward very rapidly during this month, and the days will consequently become longer. The sun will cross the equator on March 20 at which date the days and nights will be practically equal. This is the time of the vernal equinox, and the time when spring is said to begin. This position of the sun is interesting as it marks the starting point for reckoning right ascension, the sun having the right ascension $0^h\ 0^m\ 0^s$ at the moment when it is on the equator. This too is the one moment in the year when the time shown by a sidereal clock is the same as that shown by a local mean time clock.

The phases of the moon for this month are as follows:

Full Moon	Mar. 3	at	4 A. M.	C. S. T.
Last Quarter	10	"	2 P. M.	"
New Moon	18	"	4 P. M.	"
First Quarter	25	"	9 P. M.	"

The moon comes nearest the earth on March 28, and recedes farthest from the earth on March 12.

Mercury will be in superior conjunction, that is it will be on the opposite side of the sun from the earth on March 2. It will be moving eastward at this time and will reach its greatest elongation east on March 27. At this same time it will also be near its greatest distance north of the sun, and will consequently be visible low in the west just after sunset.

Venus will be conspicuous as the bright object in the east just before sunrise. It will be nearly two hours west of the sun, but it will also be several degrees south of the sun. It will therefore not rise much more than an hour before the sun, and will not be very high in the sky at sunrise.

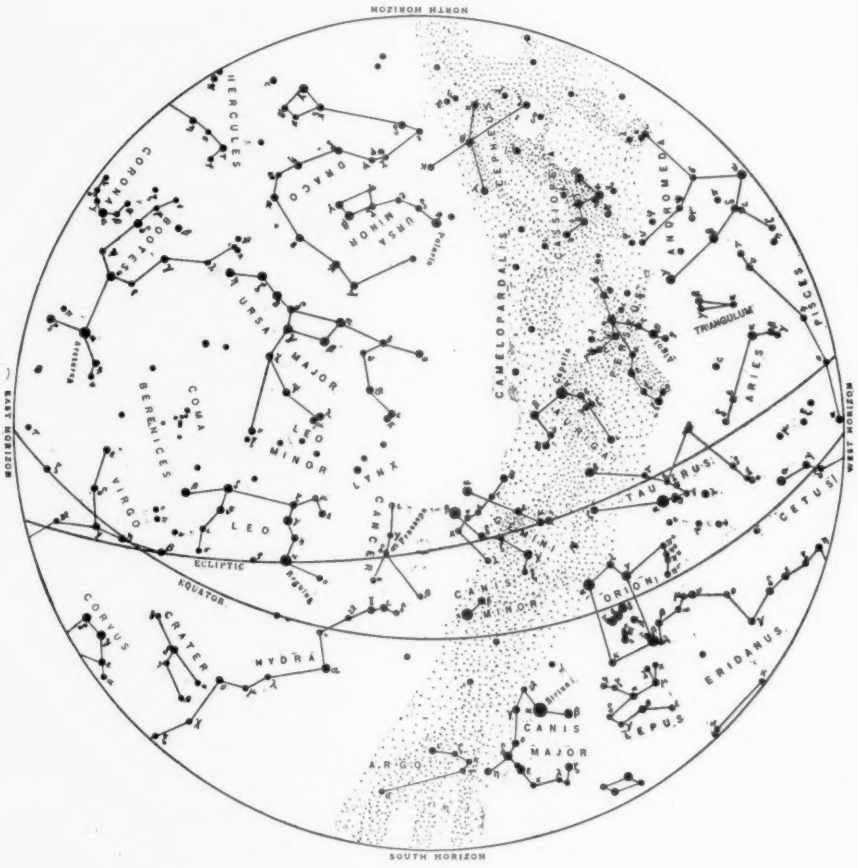
Mars will be in quadrature, ninety degrees east of the sun, on March 4. It will at that time be very near the meridian at sunset During this month Mars will be moving east at the rate of about half a degree each day, that is, it will change its position in the sky each day by a distance approximately equal to the diameter of the full moon. By the end of the month it will be, roughly speaking, thirty degrees east of the Pleiades.

Jupiter on the same date at which Mars will be in quadrature east of the sun, will be in quadrature west of the sun. Therefore on March 4 and a few days before and after that date, one of these planets will rise when the other sets. As Mars will be on the meridian at sunset, Jupiter will be on the meridian twelve hours later, that is about sunrise. Jupiter will therefore be the bright morning star during this month. Jupiter will move slowly toward the east, although the change will be so slow as to be hardly perceptible from day to day. On March 31 it becomes stationary and then begins a slow retrograde motion and continues to move slowly westward until August 2.

Saturn will move slowly eastward during the month. It will be in favorable position for observing it in the early part of the evenings during this month.

Uranus will be rather close to the sun during this month. It will rise a little before the sun, but because of its large south declination will not be in good position for observation.

Neptune will be near the meridian at sunset. It will be moving slowly westward in the constellation Gemini.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1,1912.

Occultations visible at Washington.

Date 1912	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N °	Duration h m
Mar. 8	50 B Scorpii	6.4	15 30	44	15 57	9	0 27
13	40 B Capricorni	6.2	16 27	88	17 43	254	1 16
22	τ Arietis	5.1	8 56	27	9 34	307	0 38
27	28 Cancri	6.1	6 44	116	8 05	283	1 21
27	ν^1 Cancri	5.7	8 25	79	9 28	331	1 03

Ephemeris for Physical Observations of the Sun.

[From the Companion to the Observatory 1912].

Greenwich Mean Noon 1912	P	D	L
	° ′	° ′	° ′
Jan. 1	+ 2 22	−3 5	156 56
6	− 0 4	3 39	91 5
11	2 29	4 11	25 14
16	4 52	4 42	319 24
21	7 11	5 10	253 34
26	9 26	5 36	187 44
31	11 34	5 59	121 55
Feb. 5	13 36	6 20	56 5
10	15 31	6 37	350 16
15	17 17	6 51	284 24
20	18 55	7 2	218 34
25	20 25	7 10	152 43
Mar. 1	21 44	7 14	86 51
6	22 55	7 15	20 58
11	23 56	7 13	315 5
16	24 47	7 7	249 11
21	25 28	6 58	183 16
26	25 58	6 46	117 20
31	26 17	6 31	51 23
Apr. 5	26 26	6 13	345 24
10	26 23	5 53	279 24
15	26 10	5 30	213 23
20	25 46	5 5	147 22
25	25 11	4 37	81 19
30	24 25	4 8	15 14
May 5	23 27	3 37	309 8
10	22 19	3 4	243 1
15	21 1	2 31	176 54
20	19 34	1 56	110 46
25	17 56	1 20	44 36
30	16 11	0 44	338 26
June 4	14 17	−0 8	272 16
9	12 17	+0 28	206 5
14	10 11	1 4	139 55
19	8 1	1 40	73 44
24	5 47	2 14	7 32
29	− 3 31	+2 48	301 22

Greenwich Mean Noon 1912	P	D	L
	° ′	° ′	° ′
July 4	− 1 14	+3 21	235 11
9	+ 1 2	3 52	169 0
14	3 17	4 22	102 50
19	5 31	4 50	36 41
24	7 40	5 16	330 32
29	9 46	5 40	264 23
Aug. 3	11 46	6 1	198 16
8	13 40	6 20	132 9
13	15 29	6 37	66 3
18	17 10	6 50	359 58
23	18 44	7 1	293 53
28	20 11	7 8	227 49
Sept. 2	21 30	7 13	161 46
7	22 40	7 15	95 44
12	23 42	7 14	29 43
17	24 34	7 9	323 43
22	25 17	7 1	257 43
27	25 50	6 50	191 44
Oct. 2	26 12	6 36	125 45
7	26 24	6 19	59 47
12	26 25	5 59	353 49
17	26 15	5 37	287 52
22	25 53	5 11	221 55
27	25 20	4 44	155 59
Nov. 1	24 35	4 14	90 3
6	23 38	3 43	24 8
11	22 30	3 9	318 13
16	21 10	2 34	252 18
21	19 38	1 58	186 23
26	17 56	1 20	120 29
Dec. 1	16 4	0 42	54 36
6	14 4	+0 4	348 43
11	11 55	−0 35	282 50
16	9 40	1 13	216 57
21	7 19	1 50	151 5
26	4 56	2 27	85 13
31	+ 2 30	−3 3	19 22

The position-angle of the sun's axis, P, is the position angle of the N. end of the axis from the N. point of the disc, read in the direction N., E., S., W. In computing D (the heliographic latitude of the center of the sun's disc), the inclination of the sun's axis to the ecliptic has been assumed to be 82° 45′, and the longitude of the ascending node for 1912.0 to be 74° 31′.9. In computing L (the heliographic longitude of the center of the sun's disc), the sun's period of rotation has been assumed to be 25.38 days, and the meridian which passed through the ascending node at the epoch 1854 January 1, mean noon, has been taken as the zero meridian.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on Jan. 1, 1911.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn.
X Androm.	0	10.8	+46	27	12.6 *i*	V Can. Min.	7	1.5	+ 9	2	11.0*d*
T Androm.		17.2	+26	26	8.3	R Gemin.		1.3	+22	52	9.1*d*
T Cassiop.		17.8	+55	14	11.8	R Can. Min.		3.2	+10	11	8.4
R Androm.		18.8	+38	1	6.5	RR Monoc.		12.4	+ 1	17	9.2
S Ceti		19.0	− 9	53	<11	S Can. Min.		27.3	+ 8	32	10.3
Y Cephei		31.3	+79	48	<12	U Can. Min.		35.9	+ 8	37	13.0
RW Androm.		41.9	+32	8	9.4	Y Draconis	9	31.1	+78	18	9.1
V Androm.		44.6	+35	6	10.7*d*	R Urs. Maj.	10	37.6	+69	18	8.3*d*
RR Androm.		45.9	+33	50	12.0	W Leonis		48.4	+14	15	<12
RV Cassiop.		47.1	+46	53	11.2 *i*	S Leonis	11	5.7	+ 6	0	<12
W Cassiop.		49.0	+58	1	8.8 *i*	T Urs. Maj.	12	31.8	+60	2	<11
U Androm.	1	9.8	+40	11	13.2	RS Urs. Maj.		34.4	+59	2	13.5
— Androm.		10.4	+41	12	10.0 *i*	S Urs. Maj.		39.6	+61	38	10.6*d*
S Cassiop.		12.3	+72	5	9.2*d*	R Hydrae	13	24.2	−22	46	4.7
S Piscium		12.4	+ 8	24	<12	T Urs.Min.		32.6	+73	56	13.1
RZ Persei		23.6	+50	20	12.6*d*	U Urs. Min.	14	15.1	+67	15	11.4
R Piscium		25.5	+ 2	22	9.5 *i*	S Boötis		19.5	+54	16	8.8
RU Androm.		32.8	+38	10	10.5*d*	R Camelop.		25.1	+84	17	8.6
Y Androm.		33.7	+38	50	12.5 *i*	R Cor. Bor.	15	44.4	+28	28	9.5
X Cassiop.		49.8	+58	46	<11	X Cor. Bor.		45.2	+36	35	9.7
R Arietis	2	10.4	+24	35	12.5 *i*	S Herculis	16	47.4	+15	7	9.6 *i*
W Androm.		11.2	+43	50	8.0	V Draconis	17	56.3	+54	53	10.3 *i*
Z Cephei		12.8	+81	13	13.5	W Draconis	18	5.4	+65	56	11.4*d*
o Ceti		14.3	− 3	26	9.1	W Lyrae		11.5	+36	38	9.3*d*
S Persei		15.7	+58	8	11.3	SV Draconis		31.2	+49	18	10.2
RR Cephei		29.4	+80	42	11.6	Z Lyrae		56.0	+34	49	13.9
R Triang.		31.0	+33	50	8.5*d*	V Lyrae	19	5.2	+29	30	<12
W Persei		43.2	+56	34	9.4	S Lyrae		9.1	+25	50	13.3
U Arietis	3	5.5	+14	25	11.3 *i*	U Draconis		9.9	+67	7	11.1
X Ceti		14.3	− 1	26	9.2	W Aquilae		10.0	− 7	13	<12
R Persei		23.7	+35	20	12.5	U Lyrae		16.6	+37	42	11.4*d*
W Tauri	4	22.2	+15	49	10.7*d*	TY Cygni		29.8	+28	6	<12
S Tauri		23.7	+ 9	44	<13	R Cygni		34.1	+49	58	8.1*d*
T Camelop.		30.4	+65	57	9.5 *i*	RT Cygni		40.8	+48	32	<11
RX Tauri		32.8	+ 8	9	12.9	X Cygni		46.7	+32	40	10.9*d*
X Camelop.		32.6	+74	56	8.9	RS Cygni	20	9.8	+38	28	7.3
R Orionis		53.6	+ 7	59	10.7	R Delphini		10.1	+ 8	47	<11
R Leporis		55.0	−14	57	7.6	SX Cygni		11.6	+30	46	9.2
V Orionis	5	0.8	+ 3	58	<13	V Sagittae		15.8	+20	47	11.7
R Aurigae		9.2	+53	28	11.6*d*	U Cygni		16.5	+47	35	8.7
S Aurigae		20.5	+34	4	9.2	ST Cygni		29.9	+54	38	11.0
W Aurigae		20.1	+36	49	11.3*d*	Y Delphini		36.9	+11	31	11.0
S Camelop.		30.2	+68	45	9.0	S Delphini		38.5	+16	44	11.8
SU Tauri		43.2	+19	2	10.2*d*	Y Aquarii		39.2	− 5	12	<13
Z Tauri		46.7	+15	46	13.0	T Delphini		40.7	+16	2	10.8 *i*
U Orionis		49.9	+20	10	11.9	T Aquarii		44.7	− 5	31	10.6*d*
V Camelop.		49.4	+74	30	11.7	RZ Cygni		48.5	+46	59	<12
Z Aurigae		53.6	+53	18	9.3	R Vulpeculae		59.9	+23	26	11.4*d*
V Monoc.	6	17.7	− 2	9	12.9	X Cephei	21	3.6	+82	40	<13
U Lyncis		31.8	+59	57	10.4*d*	R Equulei		8.4	+12	23	<13
S Lyncis		35.9	+58	0	11.4	T Cephei		8.2	+68	5	9.9*d*
R Lyncis		53.0	+55	28	8.4	S Cephei		36.5	+78	10	9.5 *i*

Approximate Magnitudes of Variable Stars on Jan. 1, 1912.

Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.
RT Pega	21 59.8	+34 38	<11	W Pegasi	23 14.8	+24 44	<11
T Pegasi	22 4.0	+12 3	12.0 *i*	S Pegasi	15.5	+ 8 22	8.0
Y Pegasi	6.8	+13 52	<13	ST Androm.	33.8	+35 13	8.9
RS Pegasi	7.4	+14 4	12.9	R Aquarii	38.6	−15 50	10.6
S Lacertae	24.6	+39 48	<11	R Cassiop.	53.3	+50 50	<11
R Lacertae	38.8	+41 51	10.5*d*	Y Cassiop.	58.2	+55 7	12.0
R Pegasi	23 1.6	+10 0	10.3	SV Androm.	59.2	+39 33	<12
V Cassiop.	7.4	+59 8	8.6				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— W. N. Bixby, C. E. Furness, Edward Gray, F. E. Hathorn, W. P. Hoge, C. J. Hudson, S. C. Hunter, M. W. Jacobs, Jr., W. T. Olcott, P. R. Sutton, H. M. Swartz, David Todd, H. W. Vrooman, and A. S. Young.

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by Wallace F. Johnson at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain eastern standard time subtract 5^h; Central standard time 6^h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in March 1912. d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7		22 6		
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	4 9;	12 12;	20 16;	28 19
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	9 3;	14 6;	24 11;	29 14
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	8 5;	13 18;	24 19;	30 8
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2		12 22;	27 17	
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	6 1;	11 23;	17 22;	23 21
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	4 7;	10 3;	21 20;	27 16
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	6 8;	12 10;	24 13;	30 15
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		11 0;	27 0	
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	5 5;	13 18;	22 8;	30 22
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	4 12;	15 15;	26 18	
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	4 13;	16 4;	27 19	
TT Aurigæ*	5 02.8	+39 27	7.8— 8.7	0 16.0	3 17;	10 9;	23 17;	30 9
SX Aurigæ	04.6	+42 02	8.0— 8.7	1 12.8	2 15;	8 18;	14 21;	21 0
SY Aurigæ	05.5	+42 42	9.0— 9.7	10 03.3	3 11;	13 14;	23 18	
Y Aurigæ	21.5	+42 21	9. —	3 20.6	2 21;	10 14;	18 7;	26 1
SV Tauri*	45.8	+28 05	9.4—11.0	2 04.0	7 22;	14 10;	20 22;	27 10
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	6 14;	12 3;	23 4;	28 17
RS Orionis	6 16.5	+14 43	7·8— 8.5	7 13.4	5 19;	13 9;	20 22;	28 12
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	4 2;	31 2		
57.1908 Gem.	23.7	+67 06	11.0—12.8	0 11.5	5 18;	10 13;	20 4;	24 23
W Gemin.	29.2	+15 24	6.8— 7.6	7 22.0	2 14;	10 12;	18 10;	26 8
ζ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	2 6;	12 10;	22 14	
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	6 10;	28 16		
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	3 5;	11 4;	19 2;	27 1
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	3 15;	10 8;	23 17;	30 10
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	5 3;	9 19;	19 1;	23 17
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	4 20;	13 14;	22 8;	31 2
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	6 4;	12 15;	19 3;	25 15
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	3 14;	10 6;	17 22;	23 15

Maxima of Variable Stars of Short Period not of the Algol Type.
Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in March 1912.
	h m	° ′		d h	d h; d h; d h; d h
RR Leonis	10 02.1	+24 03	9.1—10.0	0 10.9	4 4; 10 23; 24 12; 31 7
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	7 19; 16 14; 25 10
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	7 7; 13 21; 20 12; 27 2
S Muscae	12 07.4	—69 36	6.5— 7.3	9 15.8	9 10; 19 1; 28 17
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	5 12; 11 5; 22 14; 28 7
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 20; 9 14; 23 1; 29 18
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	3 22; 9 18; 21 10; 27 5
S Crucis	48.4	−57 53	6.6— 7.8	4 16 6	1 13; 10 22; 20 8; 29 17
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22.5	4 1; 11 13; 19 1; 26 13
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	16 12;
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	7 5; 14 6; 21 6; 28 8
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	2 22; 11 3; 19 8; 27 13
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	2 15; 8 3; 19 3; 24 14
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	4 2; 11 15; 19 4; 26 17
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	4 20; 12 6; 19 16; 27 2
RTriang.Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	6 12; 13 7; 20 1; 26 20
STriang.Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	6 13; 12 21; 25 12; 31 20
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	4 20; 14 14; 24 8
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9 9; 18 6; 27 2;
RV Scorpii	16 51.8	−33 27	6.8— 7.6	6 01.5	1 14; 7 15; 19 18; 25 20
u Herculis*	17 13.6	+33 12	5.1— 5.6	2 01.2	1 5; 7 9; 19 16; 25 20
RV Ophiuchi*	17 29.8	+ 7 19	9.—< 11	3 16.5	4 0; 11 9; 18 18; 26 3
X Sagittarii	41.3	−27 48	4.0— 6.0	7 00.3	3 10; 10 10; 17 11; 24 11
Y Ophiuchi	47.3	− 6 07	6.2— 7.0	17 02.9	1 4; 18 7
W Sagittarii	17 58.6	−29 35	4.8— 5.8	7 14.3	4 10; 12 1; 19 15; 27 5
Y Sagittarii	18 15.5	−18 54	5.8— 6.6	5 18.6	2 12; 8 7; 19 20; 25 14
U Sagittarii	26.0	−19 12	7.0— 8.3	6 17.9	5 13; 12 7; 19 1; 25 19
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	11 2; 21 11; 31 19
Y Lyrae	34.2	+43 52	10.5—12.	0 12.1	2 2; 8 3; 20 4; 26 5
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	5 16; 10 19; 21 0; 26 3
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	1 20; 11 18; 21 15; 31 13
β Lyrae *	46.4	+33 15	3.4— 4.5	12 21.8	13 18; 26 16
κ Pavonis	18 46.9	−67 22	4.0— 5.5	9 02.2	4 2; 13 4; 22 7; 31 9
U Aquilae	19 24.0	− 7 15	6.4— 7.1	7 00.6	7 22; 14 23; 21 23; 29 0
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	1 23; 11 7; 20 ;15 29 23
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	4 2; 13 2; 21 1; 29 9
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	1 15; 9 8; 17 0; 24 17
η Aquilae	47.4	+ 0 45	3.5— 4.7	7 04.2	1 4; 8 8; 22 16; 29 21
S Sagittae	51.5	+16 22	5.6— 6.4	8 09 2	3 19; 18 5; 24 14
X Vulpec.	19 53.3	+26 17	8.5— 9.1	6 07.7	5 5; 11 13; 17 20; 24 4
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	3 10; 10 4; 23 16; 30 10
V Vulpec. *	32.3	+26 15	8.0— 9.0	37 19.0	10 9
X Cygni	39.5	+35 14	6.4— 7.7	16 09.3	3 2; 19 11;
T Vulpec.	47.2	+27 52	5.5— 6.5	4 10.5	3 19; 12 16; 21 13; 30 10
WZ Cygni *	49.3	+38 27	9.8—10.8	0 14.0	4 3; 10 0; 21 16; 27 13
WY Cygni	52.3	+30 03	9.5—10.3	0 13.5	5 15; 11 5; 22 10; 28 1
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	2 12; 11 11; 20 10; 29 9
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	10 17; 25 11
VY Cygni	21 00.4	+39 34	8.9— 9.5	7 20.6	5 12; 13 8; 21 5; 29 2
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	2 12; 12 6; 21 23; 31 16
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.6	5 1; 13 16; 22 8; 31 0
δ Cephei	25.5	+57 54	3.7— 4.9	5 08.8	5 0; 10 9; 21 3; 26 12
Z Lacertae	36.9	+56 18	8.2— 9 0	10 21.1	3 12; 14 10; 25 7
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	5 2; 11 12; 24 8; 30 18
V Lacertae	44.5	+55 48	8.2— 8.9	4 23.6	5 1; 10 0; 20 0; 24 23
X Lacertae *	22 45.0	+55 54	8.2— 8.6	5 10.6	2 13; 8 0; 18 21; 24 8
SW Cassiop.	23 03.7	+58 12	9.2— 9.7	5 10.6	4 8; 9 19; 20 16; 26 2
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	5 4; 11 11; 24 1; 30 8
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4	5 9; 17 12; 29 16
U Pegasi	23 52.9	+15 24	9.0— 9.7	0 04.5	2 5; 9 17; 17 5; 24 17

Minima of Variable Stars of the Algol Type.

[Calculated by Mary H. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h, etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in **March** 1912.
	h m	° ′		d h	d h; d h; d h; d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.6	10 02
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	2 10; 8 09; 14 08; 20 06
U Cephei	0 53.4	+81 20	7.1— 9.2	2 11.8	5 06; 10 06; 20 05; 30 04
Z Persei	2 33.7	+41 46	9.4—12.	3 01.4	1 12; 7 15; 13 17; 19 20
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	3 21; 10 18; 17 15; 24 11
RZ Cassiop.	39.9	+69 13	6.4— 7.8	1 04.7	4 06; 10 05; 16 05; 22 04
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 12; 10 19; 21 09; 31 23
RX Cephei	2 58.8	+67 11	8.6— 9.1	32 07.6	20 10
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	9 16; 15 09; 21 03; 26 21
RT Persei	16.7	+46 12	9. —11.	0 20.4	2 12; 12 17; 22 22; 28 00
λ Tauri	55.1	+12 12	3.4— 4.5	3 22.9	5 01; 12 23; 20 20; 28 18
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	9 16; 15 05; 20 18; 26 07
RV Persei	4 04.2	+33 59	10.6—12.8	1 23.4	6 06; 12 05; 18 03; 24 01
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	1 18; 14 23; 28 03
RS Cephei	4 48.6	+80 06	9.5—12.2	12 10.1	1 00; 13 11; 25 21
RY Aurigæ	5 11.5	+38 13	10.7—11.7	2 17.5	7 12; 12 22; 18 09; 23 20
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	5 10; 11 11; 17 11; 23 12
SV Gemin;	54.6	+24 28	9.8—<11	4 00.2	1 21; 9 21; 17 21; 25 22
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 05; 12 16; 18 09; 24 03
U Columbæ	6 11.2	−33 03	9.4—10.2	2 19.2	2 15; 13 19; 19 10; 25 00
56.1908 Gem.	22.	+20 37	10.8—11.5	1 08.8	1 05; 12 04; 17 15; 23 02
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	2 18; 10 09; 17 24; 25 14
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	9 15; 21 20
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	1 07; 6 16; 17 10; 28 05
R Canis Maj.	7 14.9	−16 12	5.9— 6.7	1 03.3	5 23; 11 15; 17 07; 23 00
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	3 29; 13 12; 22 19
Y Camelop	27.6	+76 17	9.5—12.	3 07.3	4 12; 11 02; 17 17; 24 07
RR Puppis	43.5	−41 08	9.5—	6 10.3	9 12; 15 23; 22 09; 29 19
V Puppis	7 55.4	−48 58	4. — 5.	1 10.9	2 15; 9 22; 17 04; 24 11
X Carinæ	8 29.1	−58 53	7.8— 8.9	0 13.0	3 08; 14 04; 19 14; 25 00
S Cancri	8 38.2	+19 24	8. —10.	9 11.6	5 02; 14 14; 24 02
S Velorum	9 29.5	−44 46	7.8— 9.5	5 22.4	3 10; 15 07; 21 05; 27 03
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	8 21; 17 07; 25 18
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	9 23; 19 06; 28 12
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	5 23; 12 13; 19 03; 25 18
RW Urs. Maj	11 35.4	+52 34	9.3—10.3	7 07.9	1 17; 9 01; 16 09; 23 17
Z Draconis	11 40.6	+72 49	9.5—12.5	1 08.6	7 03; 13 22; 20 17; 27 12
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	2 02; 9 21; 16 22; 24 09
δ Libræ	14 55.6	— 8 07	5. — 6.7	2 07.9	4 01; 11 01; 18 00; 25 00
TW Draconis	15 32.4	+64 14	7.0— 8.9	2 19.4	8 14; 17 00; 25 10
U Coronæ	15 14.1	+32 01	7.8— 9.0	3 10.9	6 08; 13 06; 20 04; 27 01
SX Ophiuchi	16 12.6	— 6 25	10.5—11.2	2 01.5	4 01; 10 06; 16 11; 22 15
SW Ophiuchi	16 11.1	— 6 44	9.2—10.	2 10.7	7 22; 15 07; 22 15; 29 23
R Aræ	16 31.1	−56 48	6.7— 8.	4 10.2	6 03; 14 23; 23 19
TT Herculis	16 49.9	+17 00	8.9— 9.5	20 18.1	19 11;
TU Herculis	17 09.8	+30 50	9.5—12.	2 06.4	4 06; 11 01; 17 20; 24 15
U Ophiuchi	11.5	+ 1 19	6. — 6.7	0 20.1	8 22; 17 07; 25 16
SZ Herculis	36.0	+33 01	9 5—10.3	0 19.6	6 18; 14 22; 23 03; 31 07
Z Herculis	17 53.6	+15 09	6.7— 8.0	3 23.8	4 19; 12 18; 20 18; 28 18
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	1 23; 12 07; 17 11; 22 16
RS Sagittarii	11.0	−34 08	6.7— 7.8	2 10.0	1 03; 8 09; 15 15; 22 22
V Serpentis	11.1	−15 34	9 5—	3 10.9	7 01; 13 22; 20 20; 24 09
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	2 17; 13 17; 19 06; 24 18
RX Herculis	26.0	+12 32	7.8— 8.0	0 21.3	4 12; 13 10; 22 07; 31 04

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in **March** 1912. d h d h d h d h
SX Sagittarii	18 39.7	−30 36	8.6— 9.4	2 01.8	4 14; 10 20; 17 01; 23 07
RR Draconis	40.8	+62 34	9.3—13.	2 19.9	2 06; 10 18; 19 05; 27 13
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	8 01; 14 16; 21 08; 27 23
U Scuti	18 48.9	−12 44	9.0— 9.8	0 22.9	9 13; 19 02; 28 15
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.5	1 04; 19 15; 29 02
RV Lyræ	12.5	+32 15	11. —13.	3 14.4	3 23; 11 03; 18 08; 25 13
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 04; 16 03; 25 02
U Sagittæ	14.4	+19 26	6.7— 9.0	3 09.1	1 01; 7 19; 14 13; 21 08
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	4 03; 11 11; 18 20; 26 05
136.1910 Lyræ	24.3	+41 30	9.0<11.0	5 05.8	3 16; 14 03; 19 09; 24 15
SY Cygni	19 42.7	+32 28	10. —12.	6 00.2	5 20; 11 20; 17 20; 23 20
WW Cygni	20 00.6	+41 18	9.5—12.5	3 07.6	7 14; 14 05; 20 21; 27 12
SW Cygni	03.8	+46 01	9. —12.	4 13.8	7 17; 16 21; 26 00
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	5 22; 14 08; 22 19; 31 05
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 08; 12 02; 18 21; 25 16
UW Cygni	19.6	+42 55	10.5—13.	3 10.8	3 20; 10 17; 17 15; 24 12
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	9 15; 19 06; 28 20
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 03; 18 10; 27 14
Y Cygni	48.1	+34 17	7. — 8.	1 12.0	2 04; 9 15; 17 03; 24 15
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2 01; 7 3; 12 04; 22 06
VV Cygni	21 02.3	+45 23	11. —14.	1 11.4	1 24; 9 9; 16 18; 24 04
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	2 21; 12 14; 22 07; 31 23
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	6 21
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	5 14; 10 15; 20 19; 30 22
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	4 05; 9 10; 19 19; 30 03
TT Androm	23 08.7	+45 36	10.5—11.3	2 18.3	1 01; 9 08; 17 15; 25 22
32.1911 Pisc.	29.3	+ 7 22	9.0—12.0	3 18.4	4 08; 11 21; 19 10; 26 23
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	8 04; 16 10; 24 16; 28 19

Light Curve of W Ursae Majoris.—In *A. N.* 4542 Mr. O. Lazzarius of Catania gives a light curve of the variable star W *Ursæ Majoris*, based upon his own photometric observations and compared with previous light curves by Müller and Kempf and J. M. Baldwin. He obtains the following elements:

$$\text{Minimum} = 1911 \text{ July } 9\ 8^h\ 56^m \text{ Gr. M. T.} + 4^h\ 00^m\ 13^s.253\ E$$
$$= 2419046.3722 + 0^d.1668192\ E$$

Thirty-one New Variable Stars.—The thirty-one new variable stars given on page 43 of our last number have been assigned the numbers 52.1911 to 82.1911 in *A. N.* 4542. It may be of advantage to variable star observers to write those numbers in order on the margin of the page.

Three other variables discovered earlier by Espin and Backhouse and independently by Miss L. D. Wells are given as follows:

Provisional Designation	Durchmusterung No. °	Mag.	α 1900.0 h m	δ 1900.0 ° ′
83.1911 Ophiuchus	BD − 19 4644	7.8	17 23.8	−19 23
84.1911 Cygni	BD + 43 3425	8.2	19 54.0	+43 49
85.1911 Cygni	BD + 41 3632	9.5	20 06.3	+41 12

COMET AND ASTEROID NOTES.

Elements and Ephemeris of Wolf's Comet 1911 *a*.— In *A. N.* 4543 Mr. M. Kamensky gives the following elements of Wolf's periodic comet, which was picked up as the first comet of 1911, but which will not reach perihelion until February 24, 1912. The comet is only a little over 30 degrees from the sun and more than twice as distant, so that it is a difficult object to observe.

ELEMENTS.

1912 February 11.0, Berlin mean time.

$M = 358° 09' 08''.92$

$\pi = 19\ 28\ 45\ .86$

$\Omega = 206\ 39\ 34\ .88$ } 1912.0

$i = 25\ 15\ 58\ .34$

$\phi = 33\ 55\ 00\ .35$

$\mu = 521''.48129$

EPHEMERIS OF WOLF'S COMET 1911 *a*.

Berlin noon	α h	m	s	δ °	′	″	log *r*	log Δ	Aberration time m	s
Feb. 1	23	00	36.5	+0	19	06	0.2052	0.3613	19	05
3		06	24.9	0	31	53	.2044	.3627		9
5		12	13.9	0	44	58	.2037	.3640		12
7		18	03.3	0	58	20	.2031	.3654		16
9		23	53.3	1	11	59	.2026	.3667		19
11		29	43.6	1	25	54	.2021	.3681		23
13		35	34.4	1	40	03	.2017	.3695		27
15		41	25.4	1	54	23	.2013	.3709		31
17		47	16.7	2	08	54	.2010	.3723		35
19		53	08.3	2	23	34	.2008	.3738		39
21	23	59	00.1	2	38	21	.2007	.3752		43
23	0	04	51.9	2	53	15	.2006	.3767		47
25		10	43.6	3	08	13	.2006	.3781		51
27		16	35.8	3	23	15	.2007	.3796		55
29		22	27.7	3	38	18	.2008	.3811	19	59
Mar. 2		28	19.4	3	53	22	.2010	.3826	20	03
4		34	11.0	4	08	26	.2013	.3841		7
6		40	02.4	4	23	26	.2017	.3856		11
8		45	53.8	4	38	22	.2022	.3871		15
10		51	44.8	4	53	14	.2027	.3887		20
12	0	57	35.5	5	08	00	.2033	.3902		24
15	1	03	25.9	5	22	40	.2039	.3918		29
16		09	16.1	5	37	10	.2046	.3933		33
18		15	05.9	5	51	31	.2054	.3949		38
20		20	55.3	6	05	41	.2063	.3965		42
22		26	44.2	6	19	38	.2072	.3981		47
24		32	32.6	6	33	21	.2082	.3997		51
26		38	20.5	6	46	49	.2092	.4013	20	56
28		44	07.8	7	00	01	.2103	.4029	21	00
30		49	54.5	7	12	57	.2114	.4045		5
Apr. 1	1	55	40.5	7	25	34	.2126	.4061		9
3	2	01	25.8	7	37	52	.2139	.4078		14
5		07	10.3	7	49	50	.2152	.4094		19
7	2	12	53.9	+8	01	26	0.2166	0.4110	11	24

Ephemeris of Brooks' Comet 1911 *c*.—This comet is too far south for observers in the United States, but is still bright enough to be easily observed in the southern hemisphere. The following ephemeris is given in *A. N.* 4542.

EPHEMERIS OF COMET *c* 1911.

1912	α			δ		log *r*	log Δ	Mag.
	h	m	s	°	′			m
Feb. 2	15	15	10	−52	58.2			
4		16	15	53	28.5	0.29926	0.29859	8.8
6		17	08	53	58.3			
8		17	50	54	27 6	0.31206	0.30136	8.9
10		18	21	54	56.4			
12		18	39	55	24.6	0.32437	0.30378	9.0
14		18	45	55	52.3			
16		18	38	56	19.5	0.33622	0.30598	9.0
18		18	17	56	46.1			
20		17	43	57	12.1	0.34767	0.30797	9.1
22		16	55	57	37.3			
24		15	53	58	01.7	0.35871	0.30987	9.1
26		14	36	58	25.3			
28		13	04	58	48.1	0.36939	0.31167	9.2
Mar. 1		11	18	59	10.0			
3	15	09	16	−59	30.9	0.37971	0.31349	9.3

Ephemeris of Comet 1911 *c* (Brooks.)—Using the auxiliary constants given by Professor Millosevich in *A.N.* 4536 I have computed the following ephemeris of Comet 1911 *c* (Brooks) for the months of March, April and May 1912, at intervals of ten days.

The elements on which these constants are based appear to be quite accurate and were computed from observations extending over nearly two and one half months. This ephemeris shows the general course of the comet, as seen from the earth, as well as its positions on the given dates; also the logarithms of its distances from the earth and sun together with its theoretical magnitudes. The calculated magnitudes are based on the magnitude 8.1 as given by Dr. Millosevich for January 7, 1912.

This bright and interesting comet was visible to the naked eye both in the evening and in the morning. As the results of the computation show, the comet will go south to about −62° declination and then turn and begin to come north again,—being still visible in telescopes of moderate aperture the last of May.

EPHEMERIS.

Ber. M. T.	R. A.			Dec.		log *r*	log Δ	Magn.
	h	m	s	°	′			
1912 Mar. 2.5	15	10	12	−59	20.5	0.37716	0.31299	9.3
" 12.5	14	56	59	−60	50.9	0,40176	0.31784	9.4
" 22.5	14	38	01	−61	45.6	0.42460	0.32405	9.6
Apr. 1.5	14	15	08	−61	55.4	0.44588	0.33257	9.7
" 11.5	13	51	16	−61	16.3	0.46580	0.34418	9.9
" 21.5	13	29	25	−59	52.1	0.48452	0.35933	10.0
May 1.5	13	11	52	−57	53.6	0.50218	0.37818	10.2
" 11.5	12	59	11	−55	35.6	0.51886	0.40032	10.4
" 21.5	12	51	13	−53	10.9	0.53470	0.42529	10.6
" 31.5	12	47	19	−50	50.7	0.54974	0.45227	10.8

O. C. WENDELL.

Harvard College Observatory.
Jan. 12, 1912.

Ephemeris of Quenisset's Comet 1911 *f*.—This comet is now too far south for observation in the United States but may be still seen from the southern hemisphere. The following ephemeris is from *A. N.* 4543:

Berlin Midnight	α h	α m	α s	δ °	δ ′	log *r*	log Δ	Magn.
Feb. 1	15	33	42	−51	59.5	0.2140	0.2226	8.8
3		30	34	−53	31.2			
5		26	56	−55	03.2	0.2283	0.2189	8.8
7		22	45	−56	35.4			
9	15	17	56	−58	07.5	0.2421	0.2158	8.9

Ephemeris of Beljawsky's Comet 1911 *g*.—This comet is also visible only from the southern hemisphere. The following ephemeris is from *A. N.* 4543:

Berlin Midnight	α h	α m	α s	δ °	δ ′	log *r*	log Δ	Magn.
Jan. 30	18	49	16	−44	35.2	0.3607	0.4784	9.1
Feb. 1		51	59	44	57.9			
3		54	39	45	20.6			
5		57	17	45	43.4			
7	18	59	52	46	06.3	0.3825	0.4838	9.2
9	19	02	24	46	29.4			
11		04	54	46	52.6			
13		07	20	47	16.1			
15	19	09	44	−47	49.7	0.4029	0.4874	9.4

Ephemeris of Comet 1911 *h* **(Schaumasse.)**

[From A. N. 4542]

Paris Midnight	α h	α m	α s	δ °	δ ′	log *r*	log Δ	$1:r^2\Delta^2$
Feb. 2	17	37	31	− 8	21	0.0689	0.1830	0.31
6	17	54	23	8	55			
10	18	10	53	9	25	0.0696	0.1877	0.30
14		26	59	9	51			
18		42	39	10	14	0.0754	0.1944	0.29
22	18	57	53	10	33			
26	19	12	36	10	48	0.0858	0.2023	0.27
Mar. 1		26	50	11	01			
5		40	30	11	11	0.0999	0.2107	0.25
9	19	53	42	11	19			
13	20	06	22	11	25	0.1171	0.2189	0.21
17		18	30	11	29			
21		30	09	11	32	0.1363	0.2265	0.19
25		41	15	11	34			
29	20	51	53	−11	35	0.1569	0.2331	0.17

Asteroid Notes for February.—Below we give the ephemerides of four of the brighter asteroids for February. It should be noted that Vesta is at its brightest for the year. In fact it lacks but a little in brightness to make it a naked-eye object. Also note that late on the ninth or early on the tenth it will be very close to Gamma Leonis—a little less than a degree directly south of it.

Juno is still very faint, but now far enough from the sun to be easily seen. About February 12 it is very near a fifth magnitude star about eight degrees east of Zeta Ophiuchi.

On the 25th of February Pallas is very near a fifth magnitude star about four degrees to the south and east of Gamma Eridani, as will be seen by con-

sulting a star atlas with the ephemeris before one. Pallas is getting a little fainter and is of about the eighth magnitude. However, it is of sufficient brilliancy to be easily discovered.

Ceres is just beginning to grow fainter but is still very close to its brightest for the year. It was at its brightest on January 19, when it was of the seventh magnitude. It is near Castor on February 28 and still closer on March 5, when it is about a degree and a half distant.

CERES.

Date	Mag.	Right Ascension h m	Declination ° ′
Feb 4	7.04	7 49.7	+32 12
" 12		7 43.3	32 35
" 20		7 38.7	32 46
" 28	7.24	7 35.9	32 49
Mar. 5		7 35.2	+32 43
	PALLAS		
Feb. 4	7.77	3 43.7	−21 45
" 12		3 51	19 40
" 20		3 59.7	17 33
" 25		4 6	16 10
" 28	7.91	4 9.7	−15 26
	JUNO		
Feb. 4	10.39	16 57.5	−11 43
" 12		17 5.8	11 31
" 20		17 13.4	11 15
" 28	10.69	17 20.2	−10 54
	VESTA		
Feb 1		10 22.25	+18 14
" 4	6.65	10 20.4	18 35
" 9		10 15.66	19 22
" 10		10 14.7	19 30
" 12	6.60	10 13	19 47
" 20	6.58	10 5.5	20 47
" 28	6.58	9 57.7	+21 44

RUEL W. ROBERTS.

Director Ft. Pierre Observatory,
Ft. Pierre, S. D.

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions, but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Mars and the Moon December 4, 1911.—My account of my observation of Mars on December 4, as seen from Cedar Rapids, Iowa, may be helpful. The Science Hall of Coe College is in north latitude 41° 58′ 22″, west longitude 91° 40′ 38″. At 9 P. M. I decided Mars to be 4′ from the south edge of the moon, seen in a clear sky.

JUDSON W. BRUSH.

PLATE II.

Mercury and Regulus July 20, 1911.

The Southern Part of Orion.

The Southern Cross and Centaurus.

PHOTOGRAPHS OF STAR TRAILS WITH AN ORDINARY CAMERA
BY BERNARD THOMAS.

Occultation of Mars December 4, 1911.—In the last issue of P. A. an account was given of the above and the writer stated he would like to hear of any others who had witnessed the same. Early in the evening, which was an exceptionally clear one here, I noticed that the conjunction of the moon and Mars would be close as announced. Later it was seen that Mars would be occulted. At 8:45 C. S. T., the planet disappeared and did not reappear until 9:34, the occultation lasting very nearly 50 minutes. When mentioned next morning, numbers said they had noticed how close the principals were, but did not know what had occurred.

W. S. KENNEDY.

Neepawa, Man.

Editor's Note.—A rough calculation of the parallax of the moon at the places mentioned in the above notes and in the one on p. 51 of the January number of POPULAR ASTRONOMY shows that all the observers were right. At Cedar Rapids and Minneapolis there was no occultation of Mars on Dec. 4, but in South Dakota, and Manitoba the planet was occulted. It does not appear however that the occultation could have lasted quite so long in South Dakota as indicated by the observations of Mr. Roberts. The planet must have been hidden by the glare of the full moon for some time before and after the occultation.

Star Trails.—For some time now I have been experimenting taking photographs of star trails. It is surprising in many instances what a complete picture can be obtained of the brighter stars of the constellations. Using an ordinary hand camera I found the pictures very small, so I tried making a camera of my own with an inch and a half lens of about eight inches focus. This I made out of cardboard, fitting a tube on the top to act as finder. The photos enclosed are some of the results.

Mercury has been so often seen by myself with the naked eye that my first attempts were on this planet. The enclosed photo shows the bright streak formed by two minutes exposure of Mercury and the fainter mark of Regulus. About a degree separated the two and their relative brightness can be compared. The photo was taken on July 20 at 6:30 this year (1911). Mercury was at his greatest easterly elongation fourteen days later, so not at his brightest, but even then he was not much fainter than Arcturus. Considering that the middle of July corresponds to the middle of January in northern latitudes the landscape shows considerable detail.

The photo of the Cross and Centaurus will show how the solar or red type of star registers much lower on the photographic plate. α Centauri should be the brightest star and γ Crucis should be only a little inferior to β Crucis. μ Crucis, a fourth magnitude star, is nearly as bright in the photograph.

The last photograph shows the stars of Orions belt. This type of star, the Orion type, makes a strong impression; the belt is well shown; also the longer trail of the equatorial stars.

In all cases the exposure was two minutes.

BERNARD THOMAS.

Glenorchy, Tasmania.

Brooks' Comet c 1911.—I am sending you a brief résumé of my observations of Brooks' comet in the hope that it may interest some of the readers of your amateurs' department. Brooks' comet has been exceptionally interesting to the amateur, both because of its long period of visibility to the naked eye and because through its early discovery, its gradual development could be watched from a mere formless mass of haze in a telescope to a brilliant naked eye object.

The discovery of this comet was announced on July 20 and I got my first view of it on July 25 through my five-inch refractor. On that night it was situated in the constellation Pegasus and was actually many million miles from the earth and sun, but approaching rapidly. In the telescope it looked like a round, hazy patch of light of about the ninth magnitude, with a nucleus but no tail. It was not visible in a pair of field-glasses, but was like an ordinary telescopic comet, which one would little have suspected was soon to develop into a conspicuous naked-eye object. I observed it several times during the next few nights; then the moon and cloudy weather prevented further views until August 16. By this time it had increased greatly in brightness. It had now moved into Cygnus and the Milky Way region, and was very easily visible in the field-glasses as a hazy star of about the sixth magnitude. On the next night I could see it with the naked eye very faintly when I knew just where to look for it. In the telescope it was much larger than on July 25, being now about fifteen minutes of arc in diameter. There was a suspicion of a very faint tail I observed the comet nearly every night until August 22, and then the moonlight interfered until September 12. On the latter date much further increase in brightness was apparent. The comet was easily visible to the naked eye as a hazy star of the third magnitude in the constellation Draco. In the field-glasses the head and nucleus were plainly seen, and also a slender tail several degrees long. This was the first distinct appearance of a tail that I had seen. There seemed to be a very faint second tail branching off to the southward from the head. I may remark that from this time on the best views of the comet, and especially of the tail, were obtained with the field-glass or naked eye, rather than with the telescope. On September 13 the tail was faintly visible to the naked eye, and brighter in the field glasses. I suspected a rather curious aspect to the tail which I noticed many times later. It seemed to broaden gradually from the head up to a point two or three degrees away, where it became narrow and faint, and then broadened again toward the end. The effect was that the outer portions seemed almost detached from the head. It would be interesting to find out if any such phenomenon were seen by other observers. On September 14 I estimated the magnitude of the of the comet to be 2.8 and the tail seven degrees long. In the telescope the head was a formless mass twenty minutes of arc in diameter with a very distinct stellar nucleus.

During the next two weeks the tail increased nightly in brightness and length. The northern side seemed the clearest and best defined. By the end of September the comet had reached Ursa Major, with a head of nearly the second magnitude and a tail twenty degrees long. It was now at its nearest approach to the earth, and beginning to recede, but still going nearer the sun. The motion was sufficiently rapid to be noticed in the telescope in an interval o only half an hour. During the first week of October, it began to be visible before sunrise in the morning, and on October 8 I saw it both in the morning, and evening. My last view of it as an evening comet was on October 10.

It was now close to perihelion and was at its best. On October 26 it was a conspicuous object in the morning sky, the head being fully of the second magnitude and the tail twenty-five degrees long. It bore a striking resemblance to Halley's comet as seen early in May, 1910. There was the same bright nucleus, and peculiar steel-grey color to the tail. The southern side was the brightest and there seemed to be a faint second tail branching off to the north.

Beginning in the first week in November a very rapid diminution of brightness set in, partly due to the comet's becoming involved in the light of the dawn. On November 3 it was still conspicuous, but by November 13 was below the third magnitude. On November 3 the tail was bifurcated near the end, and also seemed curved a little towards the south. After this date few details could be seen on account of the growing faintness of the comet. It was a little above the fourth magnitude on November 17, which was the last time that I saw it with the naked eye. I followed it with the field-glasses a little longer, my last observation being on November 27, more than four months after its discovery.

Thus it was visible to the naked eye continuously (excepting in the moonlight) from August 17 to November 17, a period of just three months. It proved to be a most interesting object, even from a mere spectacular point of view, and has, I hope, awakened in many amateurs a greater interest in comets, and induced them to watch more closely these mysterious objects.

GEORGE F. NOLTE.

Larchmont, N. Y. Dec. 27, 1911.

Mock Moons.—An unusual phenomenon was observed here Thursday January 4. What I saw was (6:20 and later) a cross over the moon, with width of arms equal to the moon's apparent diameter and parallel sides. In brightness the cross was equal to that of a streak of sunlight shining between the clouds. It was 20° long, parallel and at right angles to the horizon. On either side, 26° distant, was a mock moon about 20° long with the middle part as bright as the rainbow, with a short projection in the middle, in the opposite direction from the moon, (part of a parhelion). 54° above the moon was a 26° halo, having a point 20° above it for a radius; its central portion also had the rainbow hues. The north end of the 26° halo extended between the two pointers in (the dipper) Ursa Major.

I have just received news that the small halo, large halo, parhelic rings, tangent bow, and vertical column, all five were more or less clearly defined on Monday night January 8, as seen at Iowa City, Iowa.

JUDSON W. BRUSH.

Cedar Rapids, Iowa, 508 5th Ave.

Comet Borrelly.—Conjunction of the Moon and Mars.—The Comet Borrelly, (1905 II; 1911 *e*) has been observed here with 3-inch refractor, (equatorial), on the nights of 1911, November 29, December 11, 19, 24, and 28. These observations show that the comet is, at least apparently, a little body, (resembling through the telescope a very small hazy mass), somewhat oval in outline, with an almost stellar nucleus of between the 10.0 and 10.5 mags., rather eccentrically placed toward one end. During the lapse of the observations the object has changed little in aspect and gained very slightly in brightness, it being at the present time at about its best.

A rather close conjunction of the moon and Mars occurred here on 1911, Dec. 4^d 9^h 47^m C.S.T., and was witnessed to good advantage with the naked eye and with the aid of the 3-inch refractor. Telescopic observations of this phenomenon were begun at 8^h 55^m. At 9^h 15^m, the moon and Mars were separately distinguishable to the unaided eye only with careful scrutiny, the planet appearing as a small red star, just a bit *s. f.* the moon's disc, and almost entirely lost in the effulgence of light issuing from the latter. At about 9^h 28^m, Mars was roughly 5′ distant from the moon's S. limb, and at 9^h 44^m. the two objects were separated by approximately 6′ 30″ or 7′ of arc (but these later estimations are doubtless considerably in error, inasmuch as I was afterwards led to the conjecture that this distance could not have appreciably exceeded 4′). Observations of the conjunction were terminated at 10^h C. S. T. On the whole as seen here the phenomenon was very attractive, especially in point of contrast between the moon and the planet. They were visible in the field of view of the telescope simultaneously, so that an excellent opportunity was afforded for a close comparison of the two bodies, special attention being directed to the apparent sizes and the colors of the discs, respectively. With power 126 diameters, the planet during moments of good seeing, showed up clearly, the most prominent features of the hemisphere being very plain, but to all appearances there was no trace of the polar cap. The silvery whiteness of the moon was, of course, intensified all the more by the very pronounced ruddiness of the planet.

FREDERICK C. LEONARD.

1338 Madison Park, Chicago, Ill.,
December 31, 1911

Lunar Halo.—Last evening we had a brilliant display in the heavens, which no one here seems to ever have witnessed, a diagram of which I enclose. The moon was some distance above the horizon, a bright spot first appeared on each side, and gradually formed a large circle and a streak across the circle each way. A rainbow as marked in diagram was directly overhead and a circle without color around the whole sky, at the same height above the horizon as the moon, with a spot in the circle in the south west, and one in the northwest.

The thermometer was 6° below zero, wind in the east, the air a little hazy with frost.

I would like to know if this often happens. I have never seen anything like it here before.

C. D. FERGUSON.

Morrill, Neb., Jan. 6. 1912.

A Brilliant Meteor.—On the morning of January 13, 1912 at 6:40 Eastern Standard Time, weather being very cold,—10° F., and sky very clear, I observed an exceedingly brilliant meteor almost over the sunrise point, moving from N. E. to S. W. and near the horizon, starting about 10° above the horizon and ending almost at it. Even in the bright dawn (half an hour before sunrise) its color was a brilliant light yellow and the straight bright trail of the same color lasted at least a minute, but the streetcar I was in at the time turned a corner before it faded, so I was unable to get the full time. Although in the strong light of the approaching sun, it was as much brighter than Venus as she is than Jupiter, both of which were in conjunction in the S.E.

WM. C. BOND.

Boston, U.S.A. Jan. 16, 1912.

Question.—Designation of Variable Stars.—Please explain fully the designation of variable stars as used in lists of them, e.g. ST Androm, RS Pegasi, X Cygni, etc.

ANSWER.—When but few variable stars were known it was customary to designate them by the capital letters toward the end of the alphabet, beginning with R, in the order of discovery in each constellation; thus R Cygni means the first variable discovered in the constellation Cygnus, S Cygni the second, R Andromedæ the first discovered in Andromeda, T Vulpeculæ the third discovered in Vulpecula, etc. Variable stars, however, multiplied so rapidly that the nine letters from R to Z were soon used up. In order to extend the notation without making a radical change the following plan was adopted by the Variable star committee of the *Astronomische Gesellschaft*:

10 = RR	19 = SS	28 = TU	37 = UX	46 = WX
11 " RS	20 " ST	29 " TV	38 " UY	47 " WY
12 " RT	21 " SU	30 " TW	39 " UZ	48 " WZ
13 " RU	22 " SV	31 " TX	40 " VV	49 " XX
14 " RV	23 " SW	32 " TY	41 " VW	50 " XY
15 " RW	24 " SX	33 " TZ	42 " VX	51 " XZ
16 " RX	25 " SY	34 " UU	43 " VY	52 " YY
17 " RY	26 " SZ	35 " UV	44 " VZ	53 " YZ
18 " RZ	27 " TT	36 " UW	45 " WW	54 " ZZ

This provided for 54 variables in each constellation, but this number has already been exceeded in the constellation Cygnus, so that we now find in use such a designation as AE Cygni, the 59th variable star discovered in Cygnus (See also P. A. Vol. X p. 332).

NOTES FOR OBSERVERS.

A Nebula and Star Cluster Section of the S. P. A. has just been formed, with Mr. H. L. Thomas of Stuart, Neb., as director.

The Monthly Report of the American Association of Variable Star Observers.—The weather, as might be expected at this time of the year, has somewhat interfered with the observation of variables during the past month. Then, too, many of our members are just starting in on the work, and struggling with its initial difficulties. It will gratify the new members to know that Dr. Edward Gray, of Eldridge, Cal., an enthusiastic observer of variables, has prepared an article on the initial difficulties encountered in the observation of variable stars, which appears in this number of "POPULAR ASTRONOMY".

Two new members have lately joined the Association:—Mr. A. B. Coe, of Portland, Oregon, and Mr. Willis L. Barnes, of Charlestown, Ind. There are now twenty-six observers coöperating in this work, representing fifteen states in the union.

SS Cygni, has again been in the limelight. It rose rapidly December 15, exactly forty-eight days from its last sudden increase in brilliancy. I am indebted to Mr. Charles L. Brook, Esq., Director of the V. S. S. of the B. A. A. for the following observations of this star, confirming our observations:—

Dec. 15 8:50 P. M. 9.45 Mag.
" 16 7:40 P. M. 8.40 "

VARIABLE STAR OBSERVATIONS Dec. 10, 1911 to Jan. 10, 1912.

TABLE I.

	Observers	Olcott 3″										Vrooman 5″				Miss Young 8″				
	Dates	10	13	17	18	19	20	23	25	28	29	7	11	13	18	22	13	18	3	4	5
1	T Androm.	8.8				8.5						8.5					8.8		8.0		
2	ST Androm.	8.8				8.5						9.0									
3	R Aquarii		10.0																		
4	S Aquarii		10.3																		
5	T Aquarii	9.2		9.5																	
6	R Aurigae	11.0																			
7	W Aurigae	11.0																			
8	R Camelop.	8.6	8.4	8.4		8.4		8.6			8.6	8.7									
9	V Camelop.				11.3																
10	X Camelop.				8.9				8.7			9.2						8.4	8.8		
11	R Can. Min.		8.0			8.0															
12	V Cancri		11·0																		
13	V Cassiop.	10.0			9.4							8.7									
14	S Cephei	9.6		9.6			9.4	9.4			9.5	9.5									
15	T Cephei	8.6		9 2				9.6			9 8	10.0	8.6		9.2	9,2					
16	o Ceti	8.8		9.0		9.0						9.2		9 2							
17	R Cygni		6.5	6.7			6.8		7.0		7.0			7.7							
18	U Cygni		9.2		9.2		9.4	9.2			9.2	8.8									
19	χ Cygni		9 8		10.3						10.5										
20	RS Cygni		7.3	7.8		7.8		8.0			7.5	7.8									
21	SS Cygni	11.3	11.3	8.3	8.5	8 3	8.3	8 3	8.7	9.5	10.0								11.7		
22	U Gemin.					11.5															
23	S Lyncis		9.9		10.3				11.0			11.0									
24	U Lyncis		9.9		10.0							10.8									
25	W Lyrae		8.9	8.9																	
26	R Pegasi	9.6		9.8				9.8				10.1									
27	W Persei						9.2														
28	R Piscium		11.0				10 0														8.7
29	W Tauri	10.4		10.8			10.6				10.6	10.8						10.0			

TABLE I. Continued.

	Hunter 5″			Dr. Gray 3½″								Miss Swartz 3″			Jacobs 3″						Hathorn			
	10	17	23	10	12	17	19	21	23	25	28	3	19	28	29	13	19	23	27	28	29	14	15	23	1
1													8.5												
2	8.7		8.8										9.0												
3																									
4																									
5																9.3	9.7			10.5					
6																11.4	11.3			11.5					
7																									
8							8.4			8.4															
9																									
10																									
11																									
12											8.5														
13				10.8					9.8	8.8						9.5	9.5			8.7					
14													10.0			10.0	10.0				9.7				
15				8.4		8.6			9.6						9.6	9.1	9.0				9.3	8.5			
16	9.0			9 0					9.2																
17						7.2	7.8				7.8	8.0	6.3										6.7	6.8	7.0
18					9.0	9.0			8.8				9.2			9.4	9.3			8.9					
19						10.0										10.1	10.1			10.7					
20						7.5				6.9							8.1			8.3					
21									8.5							11.9	8.2	8.4	9.1	10.0	10.2				
22		11.9	11.9																						
23																									
24																									
25																									
26																									
27	9.2																								
28																									
29																									

TABLE II.

	Vrooman				Miss Young						Dr. Gray									Hunter			Jacobs				Hathorn				Miss Swartz
	11	13	18	22	13	18	3	4	5	6	11	17	18	21	23	25	26	28	3	10	17	23	13	19	28	29	12	14	23	1	28
R Androm.	7·8		7.7	6.7																7.0											
V "																					10.6										
RU "																							10.1	10.4	10.7						
RR "																					11.9										
RW "								12.1															9.9	9.6	9.6						
SU "																										8.8					
S Bootis					11.6	10.4																									
U Arietis						8.5																									
S Aurigae									9.9																						
Z "																							8.1	8.4	8.6						
R Camelop.					10,1	9.1																									
T "						8.4																									
S "																															
X "																												10.7			
S Can. Min.					12.3																		8.9	9.1	9.1						
U " "																							11.6	11.6	11.8						
S Cassiop					11.7				11.8																						
T "					9.0				8.4														9.5	9.5	8.7						
U "																															
V "									11.1														9.6	9.2	9.1						
X "																												8.9			
W "																															
o Ceti											7.3			10.2												9.4					
R "													9.0				9.2									9.6					
R Coronae																															
X "												11.0						11.5													
RT Cygni								9,5																							
SX "					11.6																										
S Delphini					11.4																										
T "					9.2				9.0																						
Y Draconis																					8.9	8.9				8.6					
R Gemin.																															
S Herculis					11.4																										
W Herculis					9.0																										
R Leonis																															
R Leporis											7.5			7.8				7.8	7.6				9.3	9.3	8.3						
R Lyncis					11.2				11.0																						
R Orionis																				11.9											
U "																															
W Pegasi		10.5																		11.0											
Y Persei					8.0				9.6																						
R Triang.					9.6				9.5																						
SU Tauri							8.2									7.9							7.4	7.5		8.0	7.9	8 0	8.2		8.2
R Urs. Maj.							9,3																			10.5		9.1			
S Urs. Maj.																										11.3					
U Urs. Min.																							11.0	11.2							
S Vulpec.																															

At this writing (Jan. 10th) this wonderful star is about at the limit of the powers of a 3″ glass, but may be expected to rise again suddenly about Feb. 1.

Mira is about at its minimum now. The date of minimum deduced from Chandler's formula is January 21. Our observations of this famous star are very accordant, which however cannot be said of that very red star RS Cygni, the light of which appears to be difficult to estimate correctly.

The writer takes the liberty of quoting from a recent letter from Mr. Brook anent the observation of variables, as too much stress cannot be laid on the point he makes:—

"The most frequent cause of serious mistakes (in observation) is misidentification. New observers and experienced observers (when taking up a fresh variable) run great risks of observing the wrong star unless they thoroughly learn the field. Until you have got the configuration of the stars near the variable in your minds eye you cannot make a rapid observation, but must carefully go over the stars one by one. Further, the nearer the magnitude is to the limit of the observer's optical power the more the error comes into play."

All observers are urged to take note of this caution: In order that the report may go forward promptly each month, will observers kindly mail their to the writer by the *ninth* of each month. This is of course in addition to the lists of observations which the members of this association send by the first of each month to Professor E. C. Pickering, Director of the Harvard College Observatory.

WILLIAM TYLER OLCOTT.

Norwich, Conn., Jan. 10, 1912.

GENERAL NOTES.

A Lunar Exposition.—The Astronomical Society of Barcelona issues a circular announcing a general exposition of Lunar Studies, to be held at the University of Barcelona from May 15 to June 15, 1912. The purpose is to collect together so far as possible the principal selenographic works produced either by astronomers or amateurs or makers of astronomical instruments, so that those who are interested in lunar study in any way may see collected there everything that has been done concerning our satellite.

Stars whose Radial Velocities Vary.—In the *Lick Observatory Bulletin* No. 199 there are given lists of stars whose radial velocities have been found to be variable by the observers at the Lick Observatory and by those on the D. O. Mills expedition, at Cerro San Cristobal, Santiago, Chile. The first list contains 68 stars for which the variability was discovered at Mt. Hamilton and the second 23 accredited to the observers at Santiago.

Dr. Campbell says "The proportion of discovered spectroscopic binary systems among the stars of later spectral types has been continually increasing until it is now substantially one in four, not including numerous suspected cases. That the proportion has increased with time is what we should expect from the now well-known fact that the spectroscopic binaries among the stars of greater effective ages are characterized by long periods of revolution and low orbital velocities. In fact, we may reasonably expect that the proportional number of known visual and spectroscopic binary systems combined, among the stars of later spectral classes, will eventually equal the proportional number among the stars of classes B and A".

International Conference on Nautical Almanacs.—On October 23-26, 1911, there was held at Paris an important conference of those who are in charge of the preparation of the various national ephemerides or nautical almanacs. Representatives were present from France, England, Germany, United States, Spain, Italy, Russia, South Africa, and the Argentine Republic. The objects of the conference were to consider what steps, if any, should be taken to extend the scope of the various ephemerides for the purposes of astronomy, and at the same time to effect economy by combined action and interchange of computations. A very important resolution, passed unanimously, was "the adoption as soon as possible of Greenwich mean time as the argument for all predictions in nautical and astronomical ephemerides".

The following copy of the resolutions and recommendations adopted by the conference is reprinted from *Nature* Nov. 30, 1911:—

Resolutions and Recommendations adopted by the Conference.

The conference strongly recommends that:—

(1) In all ephemerides the ecliptic coördinates of the sun should be given for Greenwich mean noon, and that the equatorial rectangular coördinates should be given for midday and midnight of Greenwich mean time.

(2) The ecliptic coördinates of the moon should be given at least for 0h. and 12h. of Greenwich mean time.

(3) The ecliptic heliocentric and geocentric coördinates of the planets should be given for 0h or 12h of Greenwich mean time.

(4) The ephemerides of the stars, that is to say, their correction from mean to apparent place, should be calculated for upper transit at the meridian of Greenwich.

The conference is of opinion that the adoption of the meridian of Greenwich for all ephemerides should be realized as soon as possible.

The conference is of opinion that in all catalogues and all collections of observations declinations instead of polar distances should be adopted.

The conference decides that those portions of the ephemerides which deal with the data necessary for the calculation of the perturbations of the small planets and comets shall be based on the masses of the planets adopted by Newcomb.

The conference decides that the names of stars shall be accompanied by a letter indicating their spectral type in terms of Pickering's notation. It is of opinion that these indications (so far as they have been determined) should in future be given in the list of 3064 stars to be published by the Bureau des Longitudes.

The conference decides that in future the stars in the fundamental and standard lists of Auwers, Boss, and Newcomb shall de designated by the letters, A, B, N, and the Backlund-Hough stars by tne letters BH.

For the prediction of occultations of stars the list of the Nautical Almanac shall be adopted.

The commission adopts the following resolutions:—

For the sake of uniformity in the calculation of parallaxes, eclipses, and occultations, the ephemerides shall adopt for the value of the compression of the earth the number 1/297.0, resulting from the final researches of Messrs. Tittman, Hayford, and Helmert.

For like reasons, in the calculation of eclipses, the semidiameter of the sun (Auwers) shall be retained, as already employed in all ephemerides.

The bureaux charged with the calculation of eclipses of the sun and moon and the occultations of stars shall choose in common agreement the tables and apparent diameters which they find most desirable, taking care to communicate in the most precise and complete fashion the data which they employ and the origin whence the adopted data have been derived.

The conference decides that the Connaissance des Temps shall continue to calculate the positions of the sun and of the planets from the Leverrier-Gaillot tables, but that bureau will in future compute the positions of the moon from the new tables of M. Radau, which are based upon Delaunay's theory. In the other ephemerides these calculations shall be based on the tables of Newcomb and of Hill for the sun and planets, and on Hansen's tables, with Newcomb's corrections, for the moon until such a time as the latter tables shall be replaced by the new tables of Brown.

This second series of solar, planetary, and lunar calculations shall be undertaken by the Nautical Almanac Office, with the exception of the ephemeris of Mercury, for which the office of the "Berliner Jahrbuch" shall be responsible.

Relative to the Stars.

(1) The corrections from mean to apparent place of the stars BH shall be computed at the National Almanac Office, and be printed by the Observatory of Pulkowa; the same will apply to the daily corrections of the principal fundamental clock-stars, which later shall include the lunar terms of short period.

(2) The ephemerides of such of the stars A, B, N, as do not occur in the list of Auwers stars, which is published annually in the "Berliner Jahrbuch," shall be calculated and printed in the observatory at Turin.

(3) The ephemerides of the Auwers stars shall be calculated and printed by the "Berliner Jahrbuch," with the exception of the 343 stars printed within brackets; the calculation of the ephemerides of these latter shall be undertaken by L'Almanaque Nautico.

(4) The ephemerides of the pole-stars, that is to say, of all the stars situated within ten degrees of north or south polar distance which are to be found in the provisional list of 3064 stars published by the bureau des Longitudes, and of the other polar stars hitherto given in the ephemerides, shall be calculated from day to day by the Bureau des Longitudes, and shall contain the terms of short period, the values of which shall be separately indicated, however; for polar stars situated between 80° and 83° declination it will be sufficient to give the ephemerides for each alternate day.

The Connaissance des Temps undertakes to print all the ephemerides of the above-mentioned stars which are not given in other similar works.

The ordinary ephemerides of the stars shall be calculated to 0.001s. in R. A. so far as 60° of declination and 0.01″ in declination, not for each tenth day but for each tenth successive culmination at the meridian of Greenwich in order to facilitate interpolation; they will be accompanied with the data necessary for the computation of the terms of short period.

The calculation of the constants of reduction shall be carried out by each bureau in their usual way with four or five decimals.

Relative to Eclipses and Occultations.

The calculation of eclipses of the sun and moon shall be made (in conformity with the rules established by the preceding resolutions) once by the American Ephemeris and once by the Connaisance des Temps.

The computation of occultations shall be made in duplicate by the American Ephemeris.

The predictions of eclipses and the elements of occultations shall be calculated with all possible precision.

Relative to Satellites.

(1) The calculation of new ephemerides of the four principal satellites of Jupiter and their phenomena shall be made by the Bureau des Longitudes, and be based on Sampson's new tables.

(2) The ephemerides relative to the ring and to the satellites of Saturn (with the exception of Phœbe) shall be calculated by the "Berliner Jahrbuch."

(3) The calculations of the ephemerides of the satellites of Mars, of the new satellites of Jupiter, of Phoebe, and of the satellites of Uranus and Neptune shall be made by the American Ephemeris.

The ephemerides relative to physical observations of the sun, moon, planets, &c., shall be calculated by the American Ephemeris, except the ephemeris of the crater Mösting A, which will continue to be published by the "Berliner Jahrbuch."

The computation and printing of the ephemerides of the small planets and variable stars shall be undertaken by the "Berliner Jahrbuch."

It is desirable that the calculations made by any one of the bureaux should be communicated to the other bureaux, which have to use them at least three years in advance.

The above conventions will be put in force in such a way as to be complete in 1917.

It is understood that the above arrangements are provisional, subject to approval by the Governments concerned.

Astronomical and Astrophysical Society of America.—The thirteenth session of this society was held at the Carnegie Institution in Washington D. C., on Dec. 27-29, 1911. There were 64 members of the society in attendance, besides many friends. Nine new members were elected, making a total of more than 270 members.

Six sessions were held, two of which were joint meetings with section A of the A.A.A.S. At these Professor Frost presided. Our own president, Professor E. C. Pickering, was elected President of the American Association for the Advancement of Science.

Committee reports were received from the Comet and Photographic Astrometry Committees and from the Committee on Coöperation in the Teaching of Astronomy. A Committee on Asteroids was created with members E.W. Brown, Chairman, J. H. Metcalf, G. H. Peters and A. O. Leuschner.

The following is a list of members in attendance:

Misses L. B. Allen, H. W. Bigelow, A. J. Cannon, M. M. Hopkins, E. A. Lamson, Mary Proctor, S. F. Whiting.

Messrs. A. T. G. Apple, E. E. Barnard, S. G. Barton, L. A. Bauer, L. Boss, J.A.Brashear, E. W. Brown, C. A. Chant, H.S. Davis, C.L. Doolittle, E. Doolittle, R.S. Dugan, J.R. Duncan, J.R. Eastman, W.S. Eichelberger, F.E.Fowle, E.Frisby, E. B. Frost, C. H. Gingrich, A. Hall, W. M. Hamilton, J. C. Hammond, H. B. Hedrick, G. A. Hill, W. J. Humphreys, H. Jacoby, H. H. Kimball, W. F. King, F. B. Littell, F. H. Loud, E. O. Lovett, C. A. R. Lundin, Jr., J. H. Metcalf, W. I. Milham, J. A. Miller, S. A. Mitchell, W. M. Mitchell, H. R. Morgan, C. P. Olivier, G.H. Peters, E. C. Pickering, J. S. Plaskett, R. W. Prentiss, W. F. Rigge, F. E. Ross, A. L. Rotch, H. N. Russell, F. Schlesinger, A. N. Skinner, H. T. Stetson, O. Stone, E. D. Tillyer, A. B. Turner, F. D. Urie, R. W. Willson, D. T. Wilson, R. S. Woodward.

New members were elected as follows:

John August Anderson, 16 Johns Hopkins Univ., Baltimore, Md.
Zaccheus Daniel, Allegheny Observatory, Pittsburgh, Pa.
Walter H. Hamilton, 2307 Washington Circle, Washington, D. C.
H. H. Kimball, Weather Bureau, Washington, D. C.
William Francis Rigge, Creighton University.
Harlow Shapley, The Observatory, Princeton, N. J.
Vesto Melvin Slipher, Flagstaff, Ariz.
Albert Harris Wilson, Haverford, Pa.
Charles Clayton Wylie, Laws Observatory, Columbia, Mo.

LIST OF COMMUNICATIONS PRESENTED.

1. E. W. Brown. A Device for Facilitating Various Forms of Computation.
2. H. S. Davis. The Astronomischer Jahresbericht; An Announcement.
3. H. S. Davis. The Lesson of Joseph Piazzi's Life.
4. Joel Stebbins. The Variability of Polaris.
5. J. H. Metcalf. The Asteroid Problem.
6. J. A. Parkhurst. Magnitudes, Colors and Spectra of Standard Stars within Seventeen Degrees of the North Pole. (Lantern).
7. J. G. Porter. A Comparison of Doctor Peter's Celestial Charts with the Photographic Charts of the Sky.
8. G. H. Peters. The New Twin Photographic Telescope of the United States Naval Observatory. (Lantern).
9. Miss S. F. Whiting. The Use of Special Topics in teaching Astronomy.
11. J. C. Duncan. The Orbit of the Spectroscopic Binary Beta Scorpii.
12. Frederick Slocum. The Dissolution of Solar Prominences. (Lantern.)
13. Frederick Slocum. The Parallax of Nova Lacertae (1910).
14. W. J. Humphreys. A Simple Pyrheliometer.
15. F. W. Very. The Violle Actinometer as an Instrument of Precision.
16. Annie J. Cannon. The Revised Draper Catalogue.
17. H. N. Russell. Notes on the Calculation of the Elements of Algol Variables.
18. H. N. Russell. The Eclipsing Variables, W Centauri, and W Ursae Majoris.
19. J. S. Plaskett. The Solar Rotation. (Lantern).
20. F. E. Ross. The Moon's Mean Parallax.
21. Eric Doolittle. The Secular Variations of the Elements of the Orbits of the Four Inner Planets.
22. C. F. Talman (Introduced by W. J. Humphreys). The Language of Meteorology.
23. F. H. Loud. May Astronomy derive any Benefit from the Dissemination of Esperanto?
24. W. S. Eichelberger and H. R. Morgan. On the Flexure of a Meridian Circle.
25. E. S. King. Tests with Standard Electric Lamps.
26. J. A. Brashear. Recent interviews with Optical Glass Manufacturers of France and Germany.
27. E. E. Barnard. Some Observations with the 60-inch Reflecting Telescope of the Mt. Wilson Solar Observatory. (Lantern)
28. E. E. Barnard. Photographic Observations of Brooks' Comet of 1911. (Lantern)
29. F. B. Littell. Personal Equation Apparatus of the 9-inch Transit Circle of the Naval Observatory.
30. Asaph Hall. Observations of the Satellites of Uranus and Neptune made at the Naval Observatory, 1908-10.
31. W. S. Eichelberger. Paris Conference of October, 1911.
32. Zaccheus Daniel, and F. Schlesinger. The Spectrum and Orbit of Beta Scorpii.

Paper No. 10 on the preliminary program was withdrawn by Professor Frost. Abstracts of some of these papers will be presented in our next number.

Star Lore of all Ages.—A collection of myths, legends and facts concerning the constellations of the northern hemisphere, by William Tyler Olcott, with 164 illustrations and diagrams. Price by mail $3.75.

This is an interesting and attractively printed volume, which will appeal alike to those who are interested in folk-lore and those who are attracted by astronomy. Mr. Olcott has gathered together from many different sources the curious myths and traditions that have attached themselves from the earliest times to different constellations and the brighter individual stars. The book will be very useful to teachers of elementary astronomy in high schools and colleges.